ENGINEERING NEWS

A JOURNAL OF CIVIL, MECHANICAL, MINING AND ELECTRICAL ENGINEERING

Vol. [illegible] No. 3. 220 Broadway, New York, January 21, 1909.

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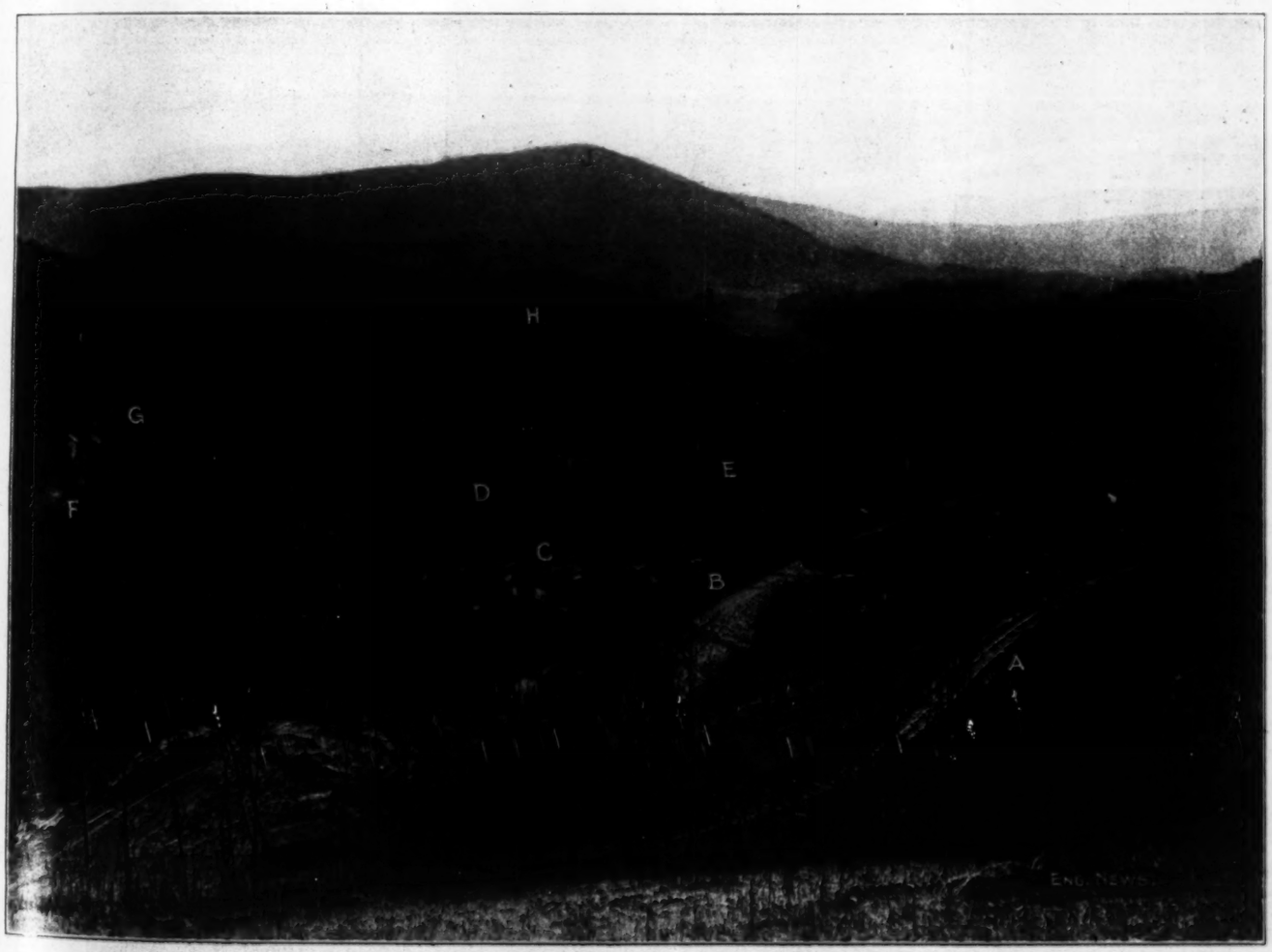
The Carolina, Clinchfield & Ohio Ry.

The development of manufacturing industries in the south has resulted in greatly increasing the southbound coal traffic, and the development of a new coal district in the southwest portion of Virginia is being undertaken with a special view to supplying the southern market. The Carolina, Clinchfield & Ohio Ry. is being built primarily to give a short and direct route from the coal fields to the industrial centers, and its owners are largely interested in the Clinchfield Coal Co., which is developing these coal fields. The railway will also give an outlet to south Atlantic ports and to the Ohio River. The road was first projected in 1888 as the Charleston, Cincinnati & Chicago Ry. and was later named the Ohio River & Charleston Ry. Some construction work was done in 1889 and 1890. About 1900, the charter was acquired by Mr. Geo. L. Carter (now President of the company), and the name was changed to the South & Western Ry. This was changed to the present name in 1907.

A heavy traffic is assured, and the railway has been built therefore with a view to a short and direct route, easy grades, and substantial construction. In this way a low cost of both operation and maintenance will be obtained, and there will be none of the future grade and curve revision work which is necessitated by increased traffic on lines built originally with a view to low first cost and light traffic. While the direct route effects a material saving in distance, it necessitates the crossing of four mountain ridges. These are the Big Sandy, Clinch, Smoky and Blue Ridge mountains, all running in a northeast-southwest direction. The Blue Ridge is the backbone of the Appalachian range. The existing railways in this section of the country



THE BLUE RIDGE SUMMIT OF THE CAROLINA, CLINCHFIELD & OHIO RY. (LOOKING SOUTH FROM A POINT ABOVE THE BLUE RIDGE TUNNEL, SEE FIG. 2).

A, Narrow gage line for hauling supplies over the ridge before the summit tunnel was finished. B, Permanent line from the summit tunnel. C, Camp No. 2. D, Pepper's Creek. E, The second pass of the loop; the Lower Pine Ridge tunnel is just to the right of this. F, Third pass of loop. G, Portal of Third Rocky Mountain tunnel. H, Line curving around to the fourth pass of the loop. I, Last leg of the loop; beyond this there is a direct run to Marion. J, Linville Mountain.

run parallel with and around these ridges. The new line was laid directly across them, and very heavy work is required to keep within the prescribed limits for grade and curvature.

This railway will extend from Elkhorn, Ky., south to Spartanburg, S. C., a distance of about 283 miles. Its general course, and its relation to the mountain ranges and the existing railways are shown in the map, Fig. 1. The line is now in operation between Johnson City, Tenn., and Marion, N. C., and it will have an outlet to the coast by a connection with the Seaboard Air Line at Bostic, N. C. The southern limit of the coal district is at Dante, in Russell Co., Virginia (244 miles from Spartanburg). This is practically a new town, developed by the coal interests. Spartanburg is an important center in the manufacturing district of the south, and has railway communication with Charleston and other south Atlantic ports. The new railway may also be extended to the coast in the future.

At Elkhorn, the line will connect with the south end of the Big Sandy division of the Chesapeake & Ohio Ry., which extends to the Ohio River and the main line at Catlettsburg, Ky. Two short pieces of existing railway have been utilized, but are being reconstructed to meet the prescribed standards as to grade, curvature and bridges. These are the Lick Creek & Lake Erie Ry. (7 miles), between Fink and Dante, Va.; and the South & Western Ry. (63 miles), between Johnson City, Tenn., and Spruce Pine, N. C.

The direction of the heavy coal traffic will be southward, and in spite of the unfavorable character of the country the maximum grade against this on the new work is 0.5%. This is, indeed, the maximum on most parts of the line. Exceptions to this are 1% grades in descending the side of the Elkhorn Valley to the Chesapeake & Ohio Ry., and 1.2% in descending the southern side of the Blue Ridge. In both cases these grades fall in the direction of the coal traffic, northbound and southbound respectively.

Fig. 1. Sketch Map of the Carolina, Clinchfield & Ohio Ry.
(Showing the four mountain ranges which it crosses.)

The highest points of the road are Dante, Va., 1,735 ft. above sea level, and the Blue Ridge Summit (152 miles south), 2,629 ft. elevation. The minimum elevation between these points is 1,200 ft., at Kingsport, Tenn., 57 miles from Dante.

Unusually heavy work is encountered in the mountains, and much direct distance is lost in order to keep within the requirements of grade and curvature. For instance, near the Blue Ridge Summit (see Fig. 2) the direct distance between two points on the main track is 300 ft., while the distance by track from one point to the other is two miles. From the Blue Ridge tunnel, the track is laid 28 miles to reach points below and opposite a direct distance of 0.3 and 4.0 miles, respectively. ... the track drops continuously to the south o... pensated grade, with the exception of three s... of 1% grade where sidings occur.

The maximum grade against the heavy ... traffic is 0.5% (compensated). Against the ... bound traffic, consisting largely of empty c... to the coal fields, the maximum grade is 1... sated). The rate of compensation provide... from the maximum grade of 0.035% for e... curve up to 9°, and 0.04% per degree for ... and over. In the reconstruction of the exist... maximum grades are reduced from 2% ag... bound traffic to 0.8% compensated, excepting ... River Gorge (8 miles), where a maximu... (compensated) is permitted.

The maximum rate of curvature is 6° on a... construction, except that 8° curves have bee... few cases on the Blue Ridge. On the temp... a maximum of 14° is permitted in place of the ... before reconstruction. Reverse curves are not ... Spirals are placed at the ends of the simple ... and upward, and between the parts of all ... curves which vary by 3° or more. The Sull... about 200 ft. in length is used.* On curves, the ... is maintained along the inner rail, and the o... raised ¾-in. for each degree of curve, up to a ... of 5¼ ins. The change from full superelevation ... level is made in the length of the spiral. On the ... structed lines, with short spirals, the reducing of super-elevation would be in some cases too abrupt if confined to the spiral length, so the reduction or run-off extends over a portion of the tangent.

In the mountain work, and particularly the Blue Ridge division, the banks are short and high. Heavy embankments are made to avoid the building of trestles or viaducts, and for the 15 miles south of the Blue Ridge summit, these structures are not found. Embankments 50 to 75 ft. high are of common occurrence, and there are many 75 to 135 ft. high. Cuts in which the upper slope line is 50 ft. above grade are frequent, and short cuts with 90 ft. difference not unusual. In deep cuts, the drilling usually does not exceed 30 ft. for holes in rock, though some of the contractors by the use of 4-in. well drills go to greater depths. In shooting the greater depths, especially in the through cuts, material is often thrown down from outside the required slopes. Black powder and 40% dynamite are the explosives commonly used in blasting rock cuts.

Several of the cuts are 120 ft. deep, ... lowing banks as high as 100 ft. The deepest c... is 135 ft., near Ashford, N. C. A tunnel wo... have been driven at this point, but the mate... al was

*Engineering News, July 3, 1902. An inspect... of the tables prepared for field use in connection ... th this easement shows it to be based on the cubic pa... bola.

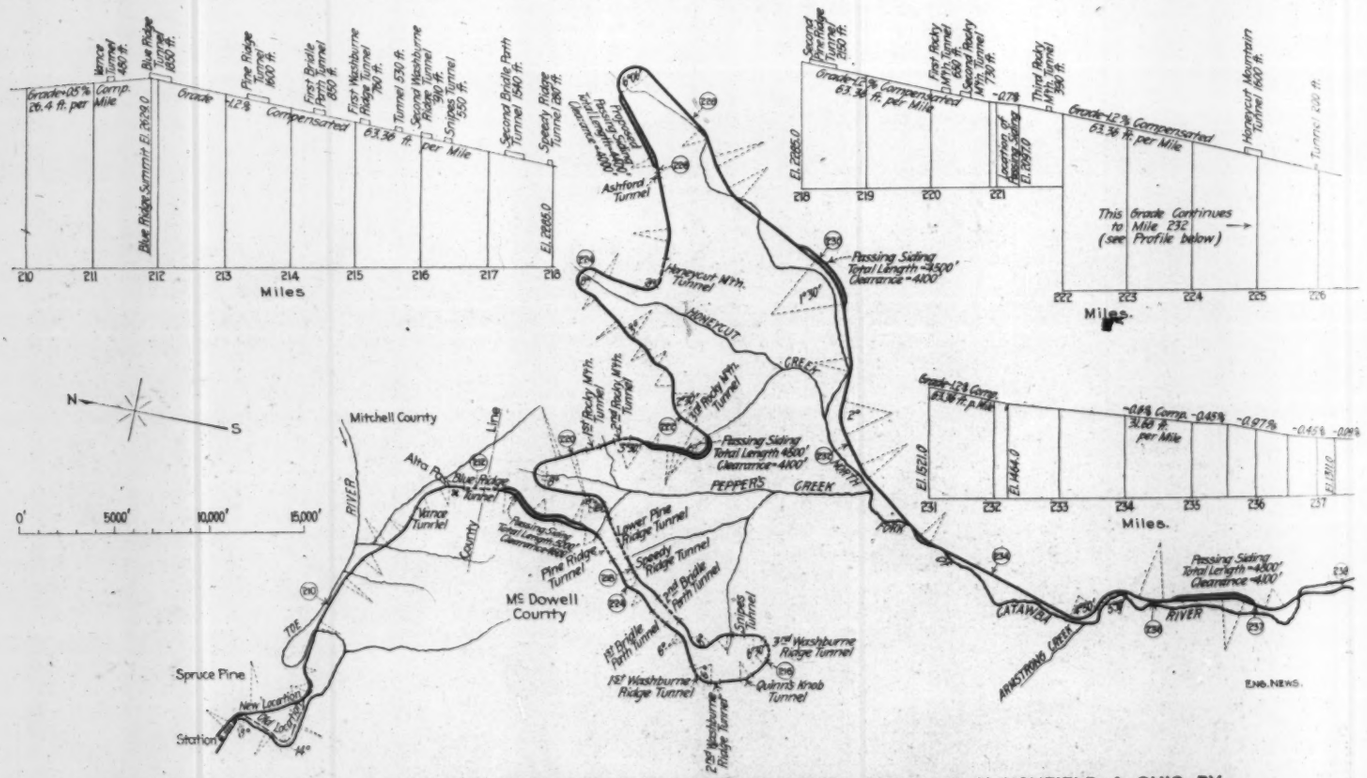


FIG. 2. PLAN AND PROFILE OF THE CROSSING OF THE BLUE RIDGE; CAROLINA, CLINCHFIELD & OHIO RY.

Topography and Construction.

The following description of the physical characteristics of the line is taken from a paper by Mr. John E. Shepardson, one of the Resident Engineers, which was read at the annual meeting of the Illinois Society of Engineers and Surveyors in 1908:

too soft. The Soldiers' Home cut, near Johnson City, is the largest in point of yardage. It is 3,000 ft. long, with a maximum depth of 85 ft. The upper 50 ft. is clay, but the lower part is in rock. The excavation was about 500,000 cu. yds. The material was hauled several miles to the bank at Knob Creek, which is 85 ft. high at its deepest point, and 2,700 ft. long. It is estimated to contain 450,000 cu. yds. The highest bank is 135 ft. high, crossing Gate Creek near Clinchport. The creek is carried through it by an 8-ft. arched culvert.

The banks were built partly by end dumping, and partly by dumping from temporary trestles. In the case of very high banks, as along the Clinch River (where the height is frequently 125 ft.) the work was handled in three lifts, using temporary trestles for each lift. For the 125-ft. bank crossing the ravine at Doe Branch (8 miles north of Clinchport) a switchback railway system was used to bring rock from the adjacent cliffs to form the embankment. The specifications for grading provide for a free haul up to 1,600 ft.; beyond this there is an extra charge for each 100 ft. of overhaul.

The section between Johnson City and Clinchport is of unusually heavy character. Thence to the crossing of Clinch River at Starnes Bend (8 miles north of Clinchport) there is sidehill work in solid rock. North of the Clinch Mountain tunnel a connection has been built to the Virginia & Southwestern Ry. at Speers Ferry. This enabled the contractors to have material delivered by rail, and eliminated a haul of 9 miles over the mountain when that tunnel was completed.

In passing from Johnson City to Spruce Pine, at the north side of the Blue Ridge, the old line of the Charleston, Cincinnati & Chicago Ry. has been followed temporarily until the new line can be built. About 20 miles south of Johnson City the road enters the gorge of the Nolichucky River, and follows it for a distance of 8 miles. In this gorge the mountain rises precipitously nearly 1,200 ft. on both sides. The conditions here and at various points are such as to attract tourist travel.

The line over the Blue Ridge was completed late in July, so that trains are operated between Johnson City and Marion, N. C., both points being on the Southern Ry. The line north of Johnson City to Clinchport will not be completed until early in 1909, but trains will be operated soon from the coal fields in Virginia, near Dante, through St. Paul and southward as far as Clinchport.

Location Over the Blue Ridge Summit.

The most interesting, and the most difficult, part of the location is the crossing of the Blue Ridge, where a considerable development is required in order to keep within the allowable limits of grade. Fig. 2 gives a plan and profile of this part of the work. The summit (2,629 ft.) is at Alta Pass, close to the north end of the Blue Ridge tunnel, and is reached by an ascending grade of 0.5% from the end of the old South & Western Ry. at Spruce Pine. Beyond this is the descending grade of 1.2%, which extends for 20 miles and is broken only where a 1% grade is introduced for passing sidings. In this distance there is a vertical fall of 1,165 ft. Between mile posts 227 and 242, the line follows the course of the Catawba River. South of Marion, N. C., it follows the valley of the Second Broad River.

The character of the country and the location may be seen by a study of the plan and profile. The view on our front page is from a photograph taken from above the south portal of the summit tunnel, looking south down the valley of Pepper's Creek (see Fig. 2). The track in the immediate foreground is the switchback narrow gage line which was used to deliver material over the mountains while the tunnel was in progress through the Blue Ridge, and until the main track was laid over the entire loop. The roadbed seen next to the foreground is that from the south end of the tunnel on the first pass of the loop.

The second pass can be seen immediately below the buildings of Camp No. 2. The crossing of Pepper Creek, in passing from the second to the third pass of this loop system, is hidden by the trees in the foreground, and is on one of the few 8° curves used on this line. The third pass of the line is seen on the extreme left of the picture, where the portal to First Rocky Mountain tunnel is shown. Under this and passing

Fig. 3. Tunnels on the Blue Ridge Crossing of the Carolina, Clinchfield & Ohio Ry., Showing Character of Strata.

around the knoll can be seen the entrance to the fourth pass of the line. The high mountain in the rear is Linville Mountain, at the foot of which flows the Catawba River (North Fork) along which the line finally extends on its way to Marion, a distance of 1,100 ft. below the summit tunnel.

Tunnels.

There are numerous tunnels on the line, especially in North Carolina. In 17 miles below the Blue Ridge Summit there are no less than 17 tunnels. The longest of these is the Lower Pine Ridge tunnel, 2,150 ft. The longest tunnel on the line now under construction is in the Clinch Mountain range which separates the valleys of the Clinch and Holston rivers. This is 4,104 ft. long. A still longer tunnel (17,000 ft. to 18,000 ft) will be required in passing through the Sandy Ridge to the Elkhorn Valley. This will be the second largest tunnel in the United States. Fig. 3 shows the Byrd, Lower Pine Ridge and Speedy Ridge tunnels (600 ft., 2,150 ft. and 600 ft.). It also shows the character of the strata penetrated.

A large percentage of the tunnel work is in hard rock of a granite character, and as a rule lining is required only at the portals, where the exposed material has disintegrated. At the Clinch Mountain tunnel the strata are almost vertical (the range having been formed by a great upheaval); as a result of this, many different qualities of rock were encountered. The hardest resembles a flinty sandstone. In this material, it took 72 hours to drill a round of 6-ft. holes, using hard tool steel and chrome steel. The ordinary depth of drill holes was 8 ft. The tunnel construction begins, as a rule, when the depth of cut exceeds 60 ft. on the center line.

The tunnel section is 18 ft. wide in the clear, with a center height of 22 ft. from the base of rail to the roof. In each side of the floor is a ditch 8 ins. deep and 14 ins. wide on the bottom. When the tunnel is on a curve its center line is placed inside the center line of track to a sufficient amount to give an equal clearance on both sides for the cars. This offset is 1 ft. for the maximum curve of 8°. The cross section of the tunnel and timbering where permanent concrete lining is needed is identical with that on the Kanawha & Michigan Ry. improvement work, which was described and illustrated in our issue of Jan. 7. From the paper by Mr. Shepardson, mentioned above, we take the following particulars of the tunnel work:

Generally speaking there are two methods employed in driving the rock tunnels of the Blue Ridge and other divisions. These are by driving (1) a bottom heading or (2) a top heading. For the bottom heading system, six vertical lines of four holes each are drilled horizontally from 6 to 10 ft. into the face of the heading, the two middle vertical lines of holes converging to the center line. The holes are shot, the muck removed and the process repeated until the entire bottom heading 18 ft. and 9 ft. above the subgrade is taken out.

The middle section, 8 ft. in height, is then removed by drilling and shooting four or five holes which extend upward and 6 ft. back from the breast of the section (the drill being on the floor of the tunnel). Another method is to drive four or five 10-ft. holes extending horizontally into the breast of the section, the drill resting on the muck pile thrown down by the previous blast on the middle section. For removing the top section or arched portion of the tunnel, eight holes are usually drilled horizontally into the breast of the section, the drill being on the muck pile thrown down by the previous shooting of the top and middle sections. Thus the bottom heading is first taken out entirely, and the balance removed in two sections. The middle section is kept a drill length or more in advance of the top section.

Where the top heading system is used, the heading is the semicircular section (9 ft. high at the center) forming the arch of the tunnel. Three vertical lines of four, three, and two holes, each 10 ft. or less in length, are drilled horizontally into the face of the heading on each side of the center line of the tunnel. The two vertical lines of four holes each converge to the center line. The holes are shot, the muck removed and the process repeated until the heading is taken out. The bench is then re-

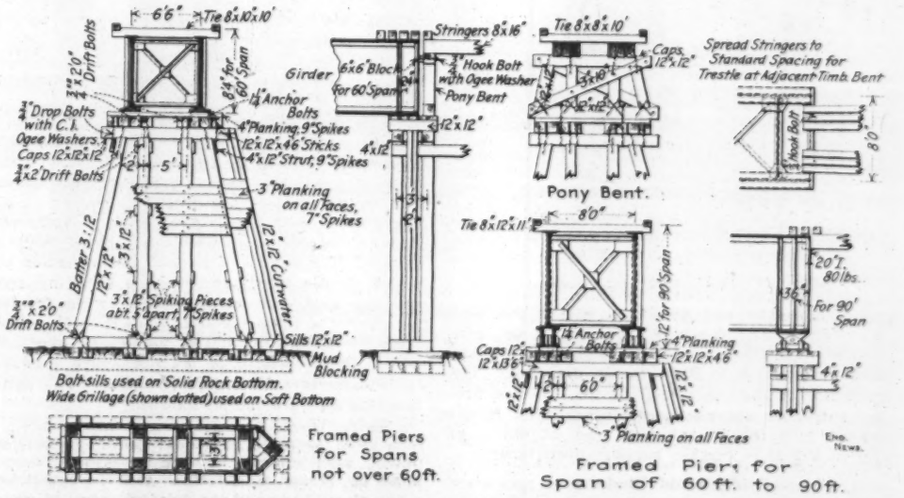

Framed Piers for Spans not over 60ft.
Framed Piers for Span of 60ft. to 90ft.
Pony Bent.
Bolt sills used on Solid Rock Bottom.
Wide Grillage (shown dotted) used on Soft Bottom
3 Planking on all Faces

FIG. 4. TIMBER PIERS FOR TEMPORARILY SUPPORTING PLATE GIRDER SPANS.

moved in two sections; the top bench drilling usually with five vertical holes, 6 or 8 ft. deep and 7 or 8 ft. back from the breast, and the sub-bench drilling with four vertical holes 8 ft. back from the breast extending to tunnel subgrade.

To secure greater freedom from fumes and quicker ventilation of the tunnel after shooting, 60% dynamite is used in the tunnel blasts, while Judson powder and 40% dynamite are employed for outside work.

Where the roof or sides are of such a nature that timbering is required, 12 × 12-in. upright posts 3 ft. c. to c. are capped by 12 × 12-in. plates from which spring the arch timbers, composed of five 12 × 12-in. chords 5 ft. long. Behind this timbering is placed the 4-in. lagging which retains the packing. Where the character of the material will permit, the timber lining is removed after the tunnel has been driven and concrete substituted. If the removal of timbering is considered unsafe, the tunnel section is increased in height and width so that the concrete lining may be constructed to the required height and clearance within the timber lining. The concrete lining is in the proportion of 1:2:5 for sidewalls and 1:2:3 for the arch ring which is 9 ft. inside diameter. The thickness of the concrete is 21 ins. Where tunnel entrances are not secure, the lining is extended into the tunnel until the character of the rock makes further support unnecessary.

Bridges and Viaducts.

The structures are of substantial construction, designed for an unusually heavy rolling load. They are mainly steel spans or reinforced-concrete arches and flat-floor bridges. Timber trestles are used only to a limited extent, solid embankments or permanent structures of steel and concrete being built in the first place, as a rule. This is one of the features in which the work differs from that of most lines in mountainous country. The comparatively light trestles on the old parts of the line are being replaced with standard girder spans supported temporarily on framed piers or bents. This construction is shown in Fig. 4.

Concrete is used almost exclusively for piers, abutments, wing walls and pedestals. It is made with broken stone, very little gravel being used. Stone of excellent quality for concrete and ballast is found along the line. In some places (especially in North Carolina), it was difficult to obtain sufficient quantities of local sand free from mica. The presence of this material greatly reduces the strength of the concrete.* Angular stones (one-man size and not over 18 ins. thick) may be used in foundations, abutments, and backing where the thickness exceeds 5 ft. They must be not less than 6 ins. apart in any direction, and at least 12 ins. from the face of the work. Concrete mixing machines were used on all large pieces of work. The date of construction is cast on all concrete structures.

The masonry plans were prepared with considerably more detail than is usual, but it is found that the increased efficiency of the work in the field more than compensates for the additional computations involved.

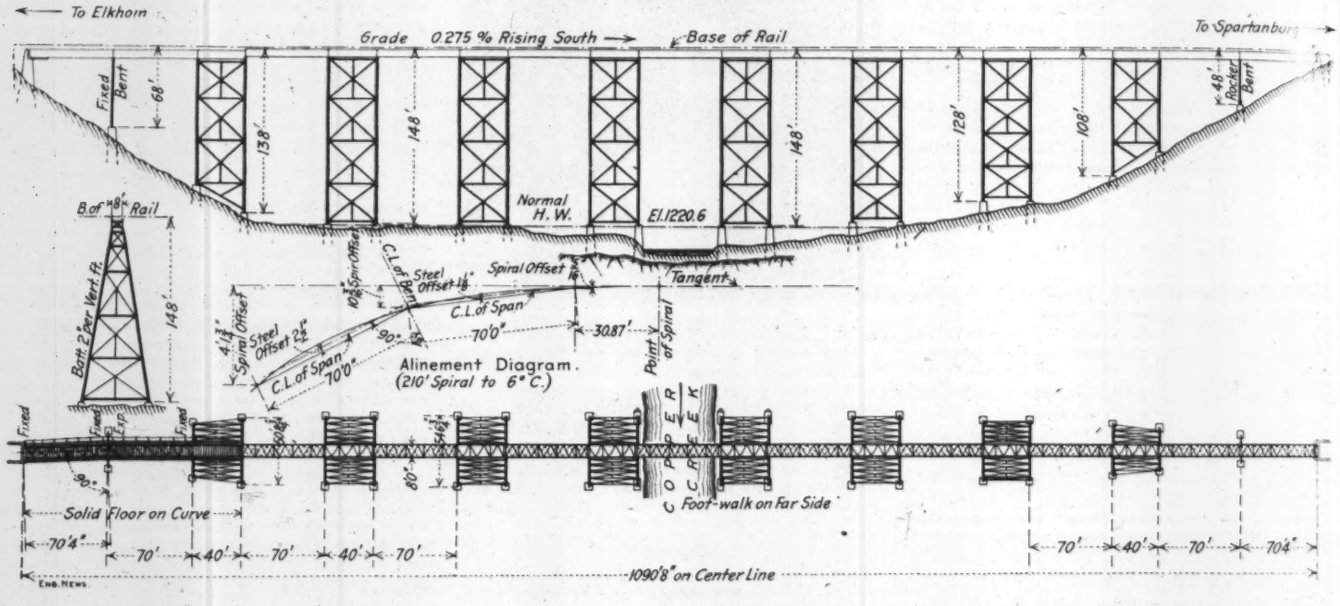
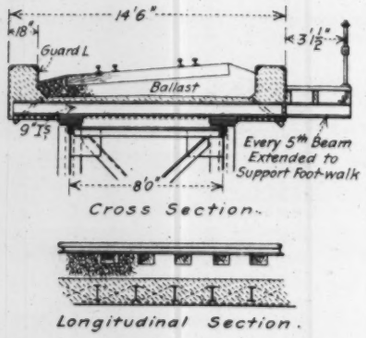


FIG. 5. THE COPPER CREEK VIADUCT; CAROLINA, CLINCHFIELD & OHIO RY.



STEEL STRUCTURES.—The loading (Cooper's Class E-60) provides for two locomotives of the 2-8-0 class, with 30,000 lbs. on the truck axle, 60,000 lbs. on each driving axle (15 ft. wheelbase), and 39,000 lbs. on each tender axle. These are followed by the unusually heavy train load of 6,000 lbs. per ft. The feature of the bracing has received particular attention on account of the enormous rolling loads to be carried and the consequent vibrations which may be caused. The effects of impact and vibration are added to the maximum stresses resulting from this live load, and are calculated by the formula in which the impact equals $S\ (300 \div (L + 300))$. Here S is the calculated maximum live load, and L is the length of loading which produces the maximum stress in the member. The specifications also provide as follows:

A moving lateral force due to wind and oscillation of train along the line of the loaded chords of girders and trusses, when alinement is straight, shall be assumed at 600 lbs. per lin. ft. of bridge. A moving lateral force acting along the line of the unloaded chords of girders and trusses shall be assumed at 200 lbs. per lin. ft. of bridge.

In viaduct towers, when the alinement is straight, the lateral force shall be taken at 600 lbs. per lin. ft. of bridge, acting 8½ ft. above the base of rail, and in addition a lateral pressure of 100 lbs. per ft. of height for each bent. For determining the anchorage, the train load shall be assumed at 2,000 lbs. per lin. ft. of track, when taken in conjunction with all lateral forces.

When the alinement is on a curve, a moving lateral force, 5 ft. above base of rail, of 175 lbs. per ft. of track for each degree of curve (with a maximum [illegible] of 875 lbs.) shall be taken in addition to the lateral [illegible] due to wind and oscillation.

Longitudinal force, due to momentum of train, [illegible] shall be taken at 20% of the total live load on the structure.

Open-hearth steel is used, and the specifications are based upon those recommended by the American Railway Engineering and Maintenance of Way Association. They provide for unit stresses of 16,000 lbs. per sq. in. in tension, and 10,000 lbs. on gross area for web shear. Ultimate tensile strength, 60,000 lbs. per sq. in. Phosphorus must not exceed 0.04% for basic or 0.08% for acid steel. Sulphur must not exceed 0.05%.

Deck and through plate girders are used for spans of 25 ft. to 100 ft., and plate girders 117 ft. long are used at the crossing of the Nolichucky River. Standard plans have been made for these bridges of 25 ft. to 90 ft. spans. The deck girders are spaced 6½ ft. apart for spans up to 65 ft., and 8 ft. apart for longer spans. Girders of 80 ft. span and over have pin-bearing shoes. (See Fig. 4.) An interesting feature of the girder bridges is that a solid ballasted floor is used for spans on curves. This consists of transverse I-beams embedded in a concrete slab, as noted below.

The truss bridges are of the riveted type, and are mainly deck spans of 120 to 150 ft. in length. Pin-connected truss spans up to 350 ft. may be required on some parts of the line not yet under construction.

There are steel viaducts up to 1,400 ft. in length, with a maximum height of 160 ft. from water level to base of rail. They are of the usual type, but in all cases horizontal struts are used in the towers. Some western roads are omitting these members, but on this point there is room for considerable argument as to secondary stresses. In some cases, also, vertical members connect these struts with the intersection points of the diagonals in the panels above them. The arrangement is shown in Fig. 5., which represents the Copper Creek viaduct. This structure has a total length of 1,360 ft., and has a height of 168 ft. from the water to the base of rail. It has plate girder spans of 40 ft. on the towers and 70 ft. between the towers. The adjacent ends of the two 70-ft. spans at the north end are supported by a spring bent. For 180 ft. at the north end (with a track curve of 6°) the viaduct has a solid floor of the type noted above. The 9-in. I-beams are embedded in 24 ins. of concrete, and there is a heavy concrete curb wall on each side. Every fifth I-beam is extended as a support for a sidewalk.

The standard bridge floor has ties 8 × 10 ins.,

*Engineering News, Feb. 6, 1908.

10 ft. long, 6 ins. apart; they are boxed out ½-in. over the girder flanges and secured to them by hook bolts in every fourth tie. The guard timbers are 8 ft. 2 ins. apart, and both these and the guard rails are the same as on the trestle bridges described later. Footwalks are required for viaducts and for all bridges over 200 ft. in length. For these, every fourth tie is 14 ft. 6 ins. long, in order to carry three lines of 12-in. plank. This is for girders spaced 6½ ft. apart. Where they are 8 ft. apart, the ties are 16½ ft. long. Alternate long ties have pipe posts for gas-pipe hand railing. For curves up to 4° with the 6½-ft. spacing of girders (and 2° 20' for the 8-ft. spacing) the superelevation is given by beveled ties. For sharper curves, a beveled block is placed on the outer girder under every tie. This is held by a hook bolt and guard-rail bolt and two 10-in. spikes. An oak key is driven parallel with the rail in a keyway formed by grooves across the tie and block.

BRIDGE ERECTION.—All steel erection work was done by means of derrick cars. One of these cars (with an 85-ft. steel boom) is shown in Fig. 6. A 35-ft. attachable extension gives a length of 120 ft. for the boom. The car is shown at work on the erection of the Catawba River viaduct. This structure is 828 ft. long. It has eight main girder spans of 60 ft., seven girder tower spans of 30 ft., one approach span of 80 ft., and a deck-truss channel span of 150 ft. In order not to obstruct the stream unnecessarily, and to lessen the cost of erection of this truss span, two timber towers were used as falsework. One-third of the span was erected complete on the first tower, after which the second tower was placed and the second part of the bridge erected upon it. The remaining part of the span was then erected, after which the necessary adjustments were made and the span was riveted up.

CONCRETE BRIDGES AND CULVERTS.—For bridges of 10 ft. to 24 ft. clear span, flat-floor reinforced-concrete structures are used, having a width of 20 ft. These have lines of 15-in. to 24-in. I-beams embedded in concrete, which is about 5 ins. thick above the beams. One of these structures is shown in Fig. 7. Wires are carried over and under the beams, and there are 1-in. rods in both directions in the bottom of the slab. These rods act as spacers for the wire-cloth which is laid in the bottom and extended into the curb walls. The rods and beams are not painted, but are brushed clean of scale and rust flakes. The floor is covered with about 15 ins. of stone ballast. The date of construction is cast in all concrete work as a record.

In the mountain sections, on account of the steep rock slopes and the denudation of the timber areas, the storm water quickly concentrates in the streams, and the culverts must have waterways of ample capacity. In the gorge of the Toe River, the high water of 1901 reached 35 ft. above average low water. For dry runs and small branches, cast iron pipe is used; from single lines of 24-in. to double lines of 48-in. pipe. Some difficulty has been encountered in a few instances by the breaking of pipe over 36 ins. diameter under embankments 40 to 90 ft. high. Track drains are of cast iron pipe not less than 14 ins. diameter.

Standard concrete arch culverts have semi-circular arches with the minimum thickness of 12 ins. for spans up to 4 ft. Where the foundation is in soft material, old rails spaced 12 ins. apart are used in the floor and bottom of the wing walls. The concrete in the end wings extends 4 ft. or more below the invert. For spans of 6 to 24 ft., the minimum height of embankment over the top of the arch is from 3 ft. in the 6-ft. span to 5 ft. in the 24-ft. span. The upstream wings are flared 30° from the axis of the arch, and those downstream are either straight or flared. The grade of the invert depends upon local conditions, but in some cases it is as high as 10%. The proportions of concrete used in the larger culverts are as follows: Arch ring, 1:2:3; side walls, wings, parapet and floor, 1:2:5; foundations and backing of arch, 1:3:6.

TIMBER TRESTLES.—These structures are used to a limited extent only, as noted above. They have 12-ft. spans supported by framed bents, the sills of each resting on four concrete pedestals 2 ft. square on top. There are two plumb posts, two batter posts (2½ ins. per ft.), a creosoted sill and a creosoted cap 12 ft. long. All these members are 12 × 12 ins. The horizontal cross braces and the sway braces are 3 × 10 ins.; the longitudinal diagonal braces are 4 × 12 ins. The material is yellow-pine.

Each stringer is composed of three timbers 8 × 16 ins., and 24 ft. long, packed 2 ins. apart. Across these are the ties 8 × 8 ins., 10 ft. long, spaced 14 ins. c. to c. Every fifth tie, however, is 8 × 10 ins., with the 10-in. side vertical; it is boxed out over the stringers, and is bolted to the stringers and guard timbers. These latter timbers are 6 × 8 ins., laid flat at the ends of the ties and boxed out 1 in. They are bolted to the large ties (as noted), and have boat spikes ½ × 10 ins. at alternate ordinary ties. The bolt heads rest in cup washers let into the timber. For trestles over 200 ft. long, the large ties are 13½ ft. long, carrying a footwalk of two planks 2 × 12 ins. and a wooden hand-railing.

Inside guard rails are used, placed 8 ins. clear from the track rails. They extend 100 ft. beyond the structure, and are brought to a point in the last 30 ft. On curves, the superelevation is given by a 10-ft. beveled cushion cap placed upon the trestle cap. This is spiked to the latter at the thinner end, while at the thick end wooden splices are spiked against the sides of the two caps. Where these caps are used, girts 6 × 10 ins. are laid upon the ends of the main caps and drift-bolted to them.

HIGHWAY BRIDGES.—The bridges carrying country highways over railway cuts are very often of light timber or steel construction. Concrete bridges have been used by some railways. We give in Figs. 8 to 10 the standard designs of this railway for timber and steel bridges of this class. The former are more generally used. These require little explanation. They are designed for loads of 80 lbs. per sq. ft. In the wooden bridges, all horizontal surfaces of the trusses and all surfaces in contact are given a liberal coat of dead-oil, woodiline or other preservative. For the steel bridges, there is a dead load of 400 lbs. per lin. ft. of truss, and a live load of 100 lbs. per sq. ft. of floor.

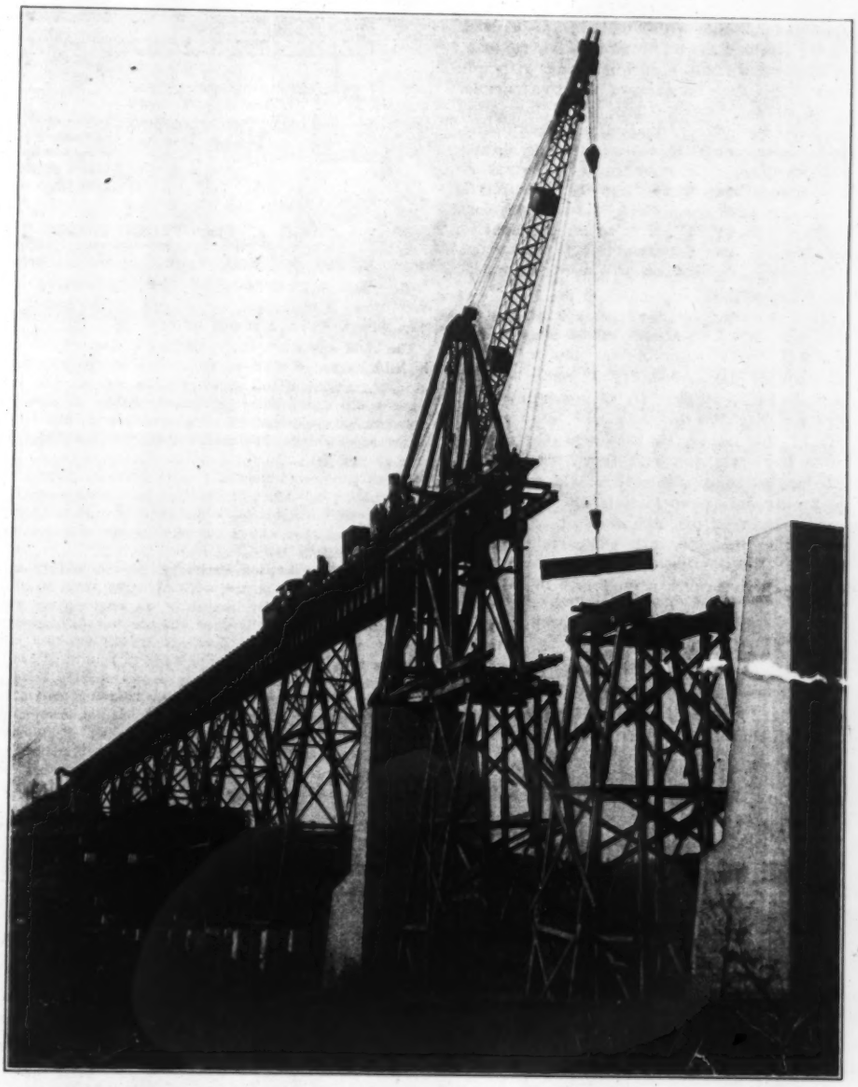


FIG. 6. STEEL DERRICK CAR ERECTING THE 150-FT. DECK-TRUSS CHANNEL SPAN OF THE CATAWBA RIVER VIADUCT.

Roadbed and Track.

The width at subgrade on the main line is 18 ft. for banks, and 20 and 22 ft. for rock and earth cuts respectively. All structures are designed for a roadbed width of 20 ft. The side ditches in rock cuts are 12 ins. wide at the bottom and 6 ins. deep. In earth cuts they are 15 ins. wide at the bottom and 8 ins. deep, though the latter depth may be increased to 20 ins. to meet unusual conditions. For important branch lines, the roadbed is reduced to 16 and 18 ft. in width for rock and earth cuts, and 14 ft. for embankments. On branch and spur lines of secondary importance, rock and earth cuts are 15 and 16 ft. wide, and embankments 14 ft. wide. To prevent scouring of slopes and the filling of track ditches, surface ditches at least 18 ins.

deep and 24 ins. wide at the bottom are dug not nearer than 10 ft. from the edge of the cut.

Crushed stone ballast, 17 ins. deep below the top of the 7-in. ties is used on the permanent construction. Suitable stone is found along the road. On the line south from Johnson City, crushed slag from local blast furnaces is used, and is 12 ins. deep below top of tie. Ties are furnished by contract and secured from the forests along the line of the road. The hardwood ties permitted are white oak, chestnut oak, post oak, chestnut and locust. The soft wood ties are long-leaf yellow pine, cypress, cedar or catalpa. Hardwood ties only are used on main line track, with white oak on the curves. First-class ties are sawed or hewed, 8½ ft. long, with a uniform thickness of 7 ins. and with not less than 7 ins. face on each of the two parallel sides. If square sawed, they are 9 ins. wide with not less than 7 ins. face. On the main line, 18 ties are used per 33 ft. rail; spurs and sidings have 15 ties per rail, or more if necessary to avoid spacing them more than 15 ins. in the clear. At the rail joints (which are suspended), the ties are spaced 16 ins. c. to c. No spacing of less than 6 ins. between ties is permitted. Steel tie-plates are used on all curves exceeding 3°, and on all bridges.

The rails for first construction are of the 85-lb. Am. Soc. C. E. section. This weight was adopted for ease of handling on new work and also in view of the probability of some bending of the rails in handling. In future renewals it is expected that 100-lb. rails will be used, on account of the heavy character of the traffic. The rails have at each end three 1 1/16-in. bolt holes 5 ins. c. to c. They are laid with suspended broken joints, no joint in the main track being more than 12 ins. ahead of or behind the center of the opposite rail. This requirement is regulated by the use of short rails. Steel shims are used to secure open joints in rail laying as follows: For a temperature of 5° below zero, 5/16-in.; and for each 25° rise in temperature up to 95° F. the thickness of the shim is reduced 1/16-in. When the temperature exceeds 100° F., the rails are laid with tight joints.

The standard width of gage is used on curves up to and including 8°; it is widened ¼-in. for curves of 9° to 12°, inclusive; and ½-in. for curves of over 12°. Several forms of six-bolt rail joints are used, including Bonzano and ordinary angle-bars 29 ins. long. The holes are alternately 1 × 1 1/16-in. (to take the neck of the ⅞-in. Harvey grip bolts) and 1 in. diameter, the bolts being entered alternately from opposite sides of the rail.

The passing sidings are usually 4,346 ft. between switch points, giving a clear length of 4,000 ft. Split switches and No. 10 spring-rail frogs are used at the turnouts.

Engineering Organization.

Mr. M. J. Caples is General Manager and Chief Engineer; Mr. A. W. Jones, Assistant Chief Engineer, and Mr. W. F. Steffens, Engineer of Bridges and Buildings. The headquarters are at Johnson City, Tenn. The Meadows Co., of the same place, has the general contract. Record of the construction work is kept in the engineer's office in a graphical manner. The profiles of the divisions are colored each month with a different tint to show at a glance the status of work at any cut, bank, tunnel or bridge crossing. The organization of the engineering department is described as follows in the paper by Mr. Shepardson, already noted:

The chief engineer (which position during construction is held by the general manager) has charge of all engineering and construction work in connection with new lines or the improvement of existing roads. A principal assistant engineer has general supervision of office work. A principal locating engineer was in charge of the location of new lines and the revision of existing lines. The locating engineers reported to and received instructions from the latter. Since the surveys have been to a great degree completed, this office has given way to the assistant chief engineer, who has general supervision over outside construction work.

There are six division engineers, each in charge of a division, which on the new work averages about 30 miles in length. They have charge of all engineering work upon their respective divisions and are responsible for its proper execution. Their divisions are divided into residencies usually of from 5 to 10 miles in length, according to the nature of the work, each in charge of a resident engineer. If inaccessible to suitable boarding places, the resident engineer is provided with quarters, comprising an office building and a bed and mess building. If he is married, he has also a three-room house for himself and family.

On new construction, the resident engineer's party consists of an assistant, a rodman, two tapemen and a timekeeper. He is responsible for the proper staking out of all work on his residency, the taking up of monthly and other estimates, and the prosecution of the work in accordance with the specifications and with the instructions of the division engineer. Construction work is let by contract in sections which vary from ¼-mile of tunnel construction to 25 miles of all classes of work. Grade camps are erected at intervals of 3 to 5 miles on the work. The common labor employed is principally the native white, the negro and the Italian.

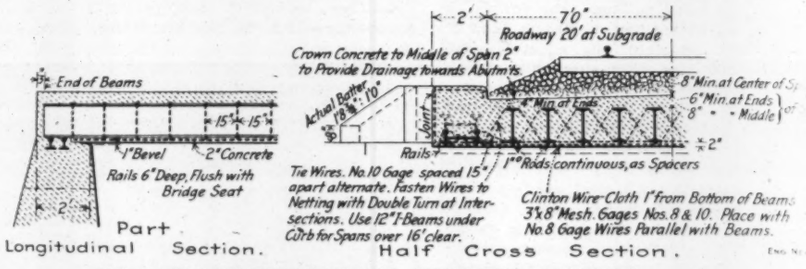

2'
70"
Roadway 20' at Subgrade
Crown Concrete to Middle of Span 2" to Provide Drainage towards Abutments
End of Beams
15" 15"
1" Bevel
2" Concrete
Rails 6" Deep, Flush with Bridge Seat
2'
Part Longitudinal Section.
Actual Batter 1'8" to 1'0"
8" Min. at Center of Span
6" Min. at Ends
8" " " Middle
4" Min. at Ends
2"
Rails
1" Rods, continuous, as Spacers
Tie Wires. No. 10 Gage spaced 15" apart alternate. Fasten Wires to Netting with Double Turn at Intersections. Use 12" I-Beams under Curb for Spans over 16' clear.
Clinton Wire-Cloth 1" from Bottom of Beams. 3'x8" Mesh. Gages Nos. 8 & 10. Place with No. 8 Gage Wires Parallel with Beams.
Half Cross Section.

FIG. 7. FLAT-FLOOR BRIDGE OF REINFORCED-CONCRETE.

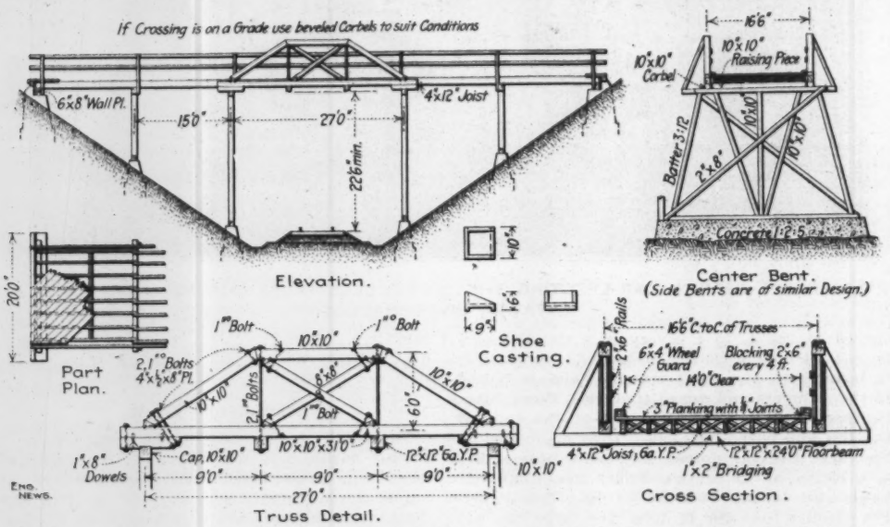


FIG. 8. STANDARD WOODEN HIGHWAY BRIDGE FOR RAILWAY CROSSINGS; CAROLINA, CLINCHFIELD & OHIO RY.

Report on the Recent First International Road Congress.*

By NELSON P. LEWIS,† M. Am. Soc. [illegible]

The Road Congress was prompted by the evident effect of modern motor cars upon the highways of France and other countries. The roll of official delegates included representatives of [30 countries, every eminent except Australia being represented, and the official attendance reaching about 1,600].

The Congress adopted a number of formal resolutions, and if the results accomplished by it are to be judged by them alone, they would appear to be very meager, the resolutions being general in character and making no pretense to a solution of the problems confronting the highway engineer. The Congress provided, however, for a permanent International Highway Commission, with headquarters in Paris, and this Commission will furnish to the members of the Congress the results of future experiments and investigations, and will, it is believed, result in great benefit to the individuals and countries which were represented. It was also decided to hold a second congress in the City of Brussels in 1910, and it is more than probable that the results of the movement inaugurated through this first Congress will be very apparent at that time, while it is to be hoped that this next Congress will be broader in its scope and will consider other municipal problems fully as important and far more complicated than the construction and maintenance of highways.

The information which the American delegates were able to acquire was due not so much to the discussions and the conclusions of the Congress as to the information presented in the various printed reports, to personal contact and conversation with different delegates, and observations of the methods of organization and the conduct of public work. In the report to be presented to the Board reference will not be made in each case to the authorship of papers from which the information is derived, but data will be given and conclusions expressed which are drawn from those papers and which were outlined briefly in a discussion submitted to the Congress by the writer. The information also acquired in the cities of Great Britain and Continental countries, with personal observations in these cities, will for the sake of logical sequence be presented in connection with the data brought out by the Congress, while all units of cost and measure are reduced to those in use in this country.

France.

It would be no exaggeration to say that the highway system of France is probably the finest in the world. Its foundation is that of the Roman roads, most of which are still in use as they were laid out and built when Gaul was a Roman province. This system is described in a paper presented by M. Renardier, Engineer-in-Chief des Ponts et Chaussees at Orleans, and is made up of five classes, namely: national roads, departmental roads, roads of great travel, roads of common interest and ordinary cross roads, aggregating in length 355,000 miles. The national roads, having a total length of some 18,600 miles, belong to the State and are maintained and improved at national expense. They are designed especially for long-distance communication, and are usually of generous width. In some cases these roads are 100 ft. wide between the side ditches, but their usual width is from 25 to 45 ft., while in mountainous regions this is reduced to 15½ and 14 ft., and in some cases to 12 ft. These national roads are the ones generally followed by motor cars. The departmental roads have a length of some 9,000 miles, and roads in this classification are constantly being reduced in mileage. Their width varies from about 37 to 22 ft., while in hilly districts they are about 15 ft. in width. Roads of great travel and of common interest are the property of the communes through which they pass, and the expense of their maintenance is supposed to be borne by these communes, although the departments allow subsidies which materially lighten the burdens upon the communes. The length of these two classes, namely, roads of great travel and

*Held at Paris Oct. 11 to Oct. 18, 1908.

†Chief Engineer of the Board of Estimate and Apportionment of the City of New York. This article is condensed from a report made to the Board just named.

of comm[illegible]erest, is now about 152,000 miles. The widths of [illegible]roads of great travel vary from 28 to 18.5 ft., while [illegible]roads of common interest are from 25 to 9 ft. in [illegible]. The fifth class, or ordinary cross roads, are stri[illegible]mmunal, and the cost of their maintenance is [illegible]by the communes, although the State and the dep[illegible]nts assist in their construction. These roads ar[illegible]signed especially to serve the interests of agricultu[illegible]nd they aggregate some 176,000 miles in length.

While [illegible]widths of roads as given above vary greatly, the extr[illegible]are due to exceptional conditions, but the general w[illegible]h of well-traveled roads is about 18½ ft., which is sufficient for two carriages to pass without reducing speed. Less frequented roads are usually given a width of 15.5 ft.

The minute attention given to drainage and other details of construction and the extreme care with which the roads are maintained are impressive to one accustomed to what must be admitted to be the slovenliness of American practice in these particulars. The side ditches are generally 5 ft. wide at the top, about 20 ins. in depth and 20 ins. wide at the bottom, and are usually protected by parapets 20 to 24 ins. in height, constructed of earth, sod or masonry.

Tree planting is made a prominent feature of the French highways, and it is said that 42%, or nearly half, of the national roads are so planted, although this practice does not prevail to such an extent on roads of other classes, as their width is not sufficient to permit it.

The French highway system has been an evolution. The work of construction and maintenance is entirely under the control of the Engineers of Bridges and Roads, a thoroughly trained corps of technical men constituting what is probably the greatest engineering organization in the world. All of the roads in commune, department or city are under their jurisdiction. There is no conflicting authority, no diversity of policy or method in contiguous departments or communes. The results have been so striking that the nationalization of highway work has lately been advocated in Great Britain. This policy is in marked contrast to that prevailing in this country, and especially in the City of New York, where in five boroughs there are five distinct highway bureaus entirely independent of each other, each one of which has its own organization, its own methods of administration and its own standards of work. The French system of nationalization might not be adapted to the conditions existing in this country, but that system has resulted in France in the best built and perhaps the most thoroughly maintained highways in the world, while in this city there is palpable waste of energy, material and money, and the results are by common consent unsatisfactory.

Some differences of opinion appear to have lately developed among the French as to the wisdom of the old policy of constant repairs, or the "stitch in time" method. As a substitute for this it has been proposed that the roads be resurfaced when required, and that they then be left alone until general resurfacing is again needed. This plan will be readily recognized as the one which prevails too generally in this country, and, so far as I could learn, it is put forward chiefly by members of automobile clubs who fancy that it would be desirable to get rid of the road workman with his cart and tools and any other of the inconveniences of repair work, so that, for a time at least, there would be nothing to interfere with the unobstructed use of the highways and the high speed of automobiles.

Few, if any, of the French engineers appear disposed to favor this change from the method which has prevailed for many years. It has been estimated that the interval which would elapse between such periodic resurfacing has been reduced fully one-half by the automobile.

The manner in which the high-speed motor cars damage the road surface was discussed in a number of the papers submitted to the Congress. Much has been said about the suction of the broad rubber tires of motor cars drawing from the roadbed the binding material upon which its life depends, and while this is in a measure responsible for the dust nuisance and the rapid deterioration of highways subjected to heavy motor traffic, it is not the chief cause of damage. Stone roads, waterbound with screenings or sand, were designed to sustain a rolling traffic, and with reasonably broad tires and moderate speed, very little damage is caused by such traffic, although the loads may be very heavy. The motor car, however, is a self-driven vehicle, the power being usually applied to the rear axle, and the rear wheels act as driving wheels. The tractive force or shear exerted upon the road surface by these driving wheels is doubtless the chief cause of the injury which is so apparent. The fine dust or binding material is not so much sucked out of the roadway by the rubber tires as it is ground out and thrown into the air by the driving wheels. The observation of a fast-moving car will show that this is the case. The dust raised by the forward wheels is slight and almost inappreciable on a road in good condition, while that raised by the rear wheels is very noticeable. This fact is brought out by the report presented by Mr. L. W. Page, Director of the United States Office of Public Roads, who was Chairman of the American Delegation to the Congress. It is also emphasized in the report of Professor Petot, of the Faculty of Sciences at Lille, who says:

The reactions of wheels which are drawn may be neglected, but those of driving wheels may be very high. As the conditions of the surface layer of the ground to which these reactions are applied are unfavorable for resisting them, they are the main cause of wear and tear on roads traveled by automobiles. Hence it should be sought to give tangential cohesion and elasticity to the top surface of the roadway by a proper choice and arrangement of the materials of which it is made.

The recent deterioration of the surface of the highways of France is very noticeable, and M. Renardier estimates that fully 1,250 miles of these roads show a marked injurious effect resulting from automobile travel, this mileage being almost entirely on the national roads, which are those most frequented by automobiles.

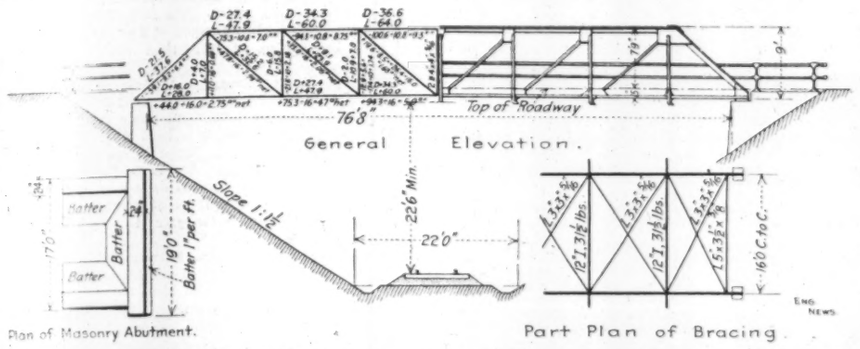


FIG. 9. STANDARD STEEL HIGHWAY BRIDGE FOR RAILWAY CROSSINGS; CAROLINA, CLINCHFIELD & OHIO RY.

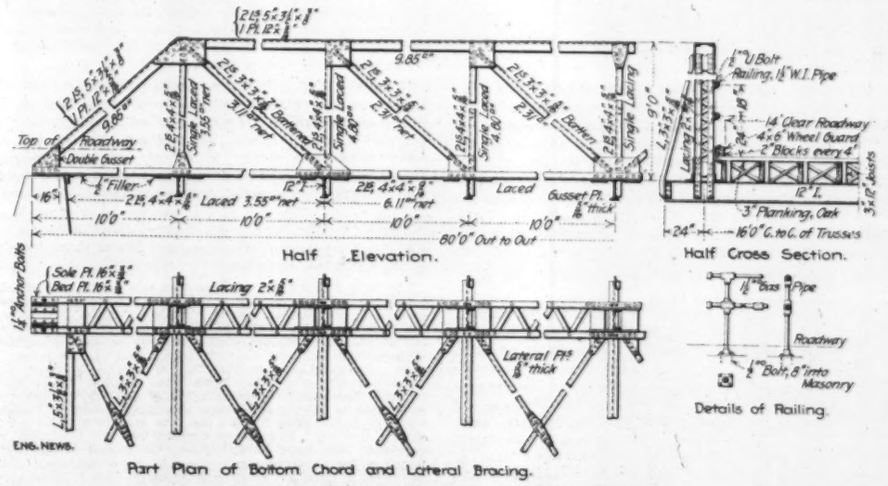


FIG. 10. DETAILS OF STEEL HIGHWAY BRIDGE.

Great Britain.

While the roads of Great Britain are excellent, the system is not as complete as that of France. The roads have not been classified, and there is not the same uniform system of construction and maintenance. The damage caused to these highways by the automobile is quite as evident as in France, and the figures presented to the Congress showing the extent of this damage are quite as impressive. Mr. G. Montague Harris, secretary to the County Councils' Association, estimates that from 1896 to 1906 the cost per mile of maintaining the English macadam roads has increased 30.9% in the case of rural main roads and 9.4% in the case of urban main roads. Statistical data relative to the main roads in Nottingham County, England, show that while the increase in the annual cost of maintaining the highways from 1895 to 1900 was 4.7%, the increase in the annual cost between 1900 and 1905 was 19.5%. That the latter five-year period was coincident with the first general use of motor cars is certainly more than a coincidence. Another paper presented to the Congress showed that within five years the annual cost of maintenance of the rural main roads of England and Wales had increased 20%, while during the same period the cost of maintaining roads of the same description in the seven counties nearest to London showed an average increase of nearly 38%, and for the year ending March, 1907, the increase in the same seven counties was nearly 48% over that obtaining in 1901. Still another delegate to the Congress estimated the rise in the annual cost of maintaining the main roads of all of England and Wales during the past six years to be 21%.

In this country accurate data concerning the life of roads and their constituent materials and the cost of repairs and maintenance have not been as intelligently kept as in Europe, but that this problem of the effect of the motor car upon our highways has forced itself upon those responsible for our roads is quite apparent. The State Engineer of New York in his last report suggests that "if the high-speed machines are to be allowed upon our highways, they should be taxed in proportion to the maximum speed of which they are capable." He has also insisted that before any speed trials or road races by automobiles are held upon any of the highways under the control of the State, there shall be deposited in his office a very substantial sum in each case, which shall constitute a guarantee fund from which shall be paid the expense of repairing the damage caused by such races.

It is needless to give further testimony as to the extent of the damage now being done and the necessity for serious consideration of the problem which is presented, and of devising some method of solution.

Roads, Automobiles and Dust.

The development of a system of good roads has always been a slow process. The Romans alone among the nations of the earth appear to have appreciated the potent influence of the highway upon civilization and commerce, and they planned and built their roads to stimulate the development of the country. Other nations have deferred their road building until the demands of traffic and the necessity for easy communication compelled it. During the last generation great progess has been made, and half a decade ago all progressive countries had not only paved their city streets with substantial, smooth and sanitary pavements, but had created systems of interurban roads in rural districts which were fairly smooth and relatively free from mud and dust, and upon which travel was comfortable and reasonably rapid with horse-drawn vehicles. Then came the motor car, and in a very few years conditions have changed to such an extent that the problem of maintaining the highways frequented by these vehicles is commanding universal attention. The cloud of dust raised by the motor car tells its own story. It means not only great discomfort for others using the road and those dwelling in its vicinity, but the very life of the structure is being taken from it. It is said that in a district near the city of New York well known for its excellent highways and in favor with the business and professional men of New York as a place of summer residence, it was formerly possible to live in entire comfort in a dwelling within a hundred feet or less of a public highway. Since the advent of

the motor car the dust nuisance along these highways has become so serious that, to insure comfort, dwellings must be placed three or four hundred feet from the highways, necessitating the purchase of much more extensive grounds. The problem is not a fad or a fancy, but an acute condition which must be met.

How can the conditions which have been outlined be improved? Three solutions suggest themselves:

(1.) The speed of motor cars can be controlled by rigidly enforced police regulations, so that their effect upon the road will be no more destructive than that of the former horse-drawn vehicle.

(2.) The motor traffic could be segregated and confined to roads built especially for it, and so constructed as to be dustless and unaffected by the rubber-tired driving wheels and high speeds.

(3.) The roads could be gradually reconstructed with a binding material which will be proof against the disintegrating forces exerted upon them by motor cars running at high speed, and pending such reconstruction the roads could be so treated as to abate, if not entirely eliminate, the present nuisance.

The first plan is undoubtedly impracticable. To effectually police our suburban and country roads and prevent running at high speed would require an army of men, would involve enormous expense and would reduce the motor car, one of the most useful and remarkable mechanical developments of recent years, to a useless toy, if not an absurdity. It would be a confession of failure to cope with the problem and would be a long step backward, and may be dismissed without further comment.

The second plan, the segregation of motor traffic upon roads especially designed for it, might be possible, but would involve either a restriction of such traffic to very few roads, or a duplication of the present highway system at enormous expense. This expense, it might be claimed, should be imposed upon those using motor cars, either by tax or toll, as in the case of the motor parkway on Long Island, a section of which has been completed and upon which were held the last Vanderbilt cup races. This would mean that the cost of motoring would be so greatly increased as to be beyond the reach of any but the very wealthy. It would also be asked why, if the roads can be built to withstand this kind of traffic, the method should not be applied to our existing highways. Special motor roads will therefore be built, if at all, by private initiative, and at private expense, as is the case with the one referred to on Long Island, and will be used only for high speeding, which would be entirely inconsistent with public safety on the highways. Such a plan cannot be considered as a solution of the problem.

The third method, then, remains for serious consideration, and it is the one which was favored in nearly all of the reports presented to the Congress which dealt with the question of construction.

It must be conceded that grit or stone dust of the same kind as that of which the road is built, sand, sandy loam and mixtures of sand and clay, are not suitable as binding material for roads, which are freely used by motor cars. As stated by M. Mauhieu, Engineer of Bridges and Roads, of Paris:

> Only a perfectly homogeneous roadway, of which all the fine surface materials are protected against being scattered, is able to stand the passage of the extra rapid vehicles in use today.

Either the roadbed must be so hard and dense as to be unaffected by the traffic or a more viscous and elastic binding material must be used. It is quite generally believed that some form of bitumen is best adapted to this purpose. Many different kinds and grades are available—asphalt, tar, pitch and oil, and there are patented mixtures as to the efficacy of which extravagant claims are made, and patented devices for their application. The bituminous material may be used in various ways, but there are four general methods:

(1.) Coating the surface to form, temporarily at least, a waterproof and dustless road.

(2.) The penetration method, by which the bituminous matter is forced down into the broken stone, and sand or screenings are used to take up the excess of bitumen.

(3.) The interposition of bituminous mixture between the bottom course of stone (in many cases the existing road) and the top course, or new wearing surface, and the forcing of the upper course into the mixture, additional material being added to the surface to completely fill the interstices between the stones, while sand or screenings are applied to take up any excess upon the surface.

(4.) The mixing method, under which the stone which is to form the wearing surface is thoroughly coated with the hot bituminous cement, with a proper amount of screenings and other fine material added to reduce the voids, the mixture being spread upon the road while hot, after which it is thoroughly rolled, as in the case of the ordinary asphalt pavement of bituminous macadam of the American type, the surface again being coated with sand or screenings, as in the other cases.

The first method, that of surface coating, can be considered temporary or palliative only. The material most commonly used is tar or oil, the latter being frequently applied as an emulsion.

The result of oil sprinkling on the parkways of Boston is given in a report presented to the Congress by Mr. John A. Pettigrew, Superintendent of Parks. The first application of the season is an emulsion containing about 16% of oil. Renewals, which are made in from 10 to 25 days, according to location and volume of traffic, contain from 8 to 10% of oil. The cost of this treatment is said to be less than that of water sprinkling by more than 45%. An oil emulsion quite similar to that used on the Boston parkways has recently been tried on the park roads in the Borough of Manhattan, but there are no data at hand to determine the cost as compared with water sprinkling. Surface applications of tar have been quite successful, and the material is applied either by sprinkling or painting. Oil sprinkling is frequently applied to soft roads; tar is successfully used only on hard macadam.

The proper method of applying tar to the surface of existing roads is given in a report presented by Colonel Charles S. Bromwell, Superintendent of Public Buildings and Grounds, Washington, D. C., and one of the delegates to the Congress, as follows:

> Before applying the tar the macadam must be brought to grade and filled with fine screenings, rolled and subjected to traffic until firm. The mechanical bond of the macadam must be as perfect as possible, and no reliance should be placed on the tar to do the binding. Crude tars must not be used, as they contain ammonia and other objectionable substances. It is best to use one or more of the prepared tar products, which fulfill the physical and chemical requirements. The work should be done only in warm, dry weather. The macadam should be swept clean, and, if necessary, brushed with wire brooms, and the surface must be perfectly dry to a depth of at least one inch before applying the tar. The tar should be applied hot, at a temperature of about 200° F., allowed to percolate several hours, and then covered with sand or fine stone screenings. Several hours after the screenings have been spread it [the road] should be rolled and additional screenings put on, if the tar squeezes up through them. Traffic should be kept from the road for several days after the rolling in order to give the tar an opportunity to penetrate and become cool.

It is generally conceded that tar can only be successfully applied in fair and warm weather and when the surface of the road is entirely dry. The cost of tar painting, or surface treatment, is estimated at about one-half that of tar macadam laid by the mixing method hereafter described. This method of surface application is much in vogue at the present time on the highways in the vicinity of Paris, and even on some of the principal thoroughfares of the city itself. Some apparently excellent results have been obtained in this way, notably on the Avenue du Bois de Boulogne, a much traveled street, where the macadam pavement when seen by the writer had almost the appearance of asphalt. Tar sprinkling or painting has many enthusiastic advocates in France, who make the most extravagant claims as to the efficacy of this treatment as a complete solution of the dust problem.

Mr. Clifford Richardson, one of the delegates of the Federal Government to the Congress, while recognizing the great temporary benefit of surface applications, concludes that attempts to save wornout roads in this way are doomed to failure. He believes that a dustless road can only be secured by the substitution of a bituminous concrete for the old type of macadam, and that in constructing such a surface asphalt will give more satisfactory results than can be secured by the use of tar.

The second, or penetration, method consists of forcing the bituminous cement into the surface of existing or new macadam roads. If applied to an existing road the surface is first loosened, after which the hot tar or other bituminous matter is spread over the loosened stones, with the addition of a certain amount of screenings or other fine material, and the surface is then thoroughly rolled. The use of this method on new roads is described by Mr. Walter W. Crosby, Chief Engineer of the Maryland Road Commission, and one of the delegates to the Congress, as follows:

> The best method yet devised seems to be that of nearly completing the macadam as if no tar were to be used, and then, instead of finally "flushing" (i. e., of filling the smallest voids with the finest sizes of stone by the aid of water), to saturate as nearly as possible the mass with refined tar heated to sufficient fluidity for penetration. Provided the irreducible interstices between the larger stones are filled with the smaller sizes down to the "flour," but the flushing in of the "flour" has not proceeded to that point where the mass would be impervious to penetration by the tar, the results will be practically perfect. Successive applications of tar may be required, and some objection may be raised to the time required for this process. It would seem, however, that in view of the at least theoretically better results to be secured in this way, and of the fact that no sacrifice in economy of materials nor of any of the principles underlying the construction of macadam is involved, that some extra length of time in the process might be justified. It is entirely possible that, in the investigations regarding the bituminous cement to be used, a vehicle for carrying it swiftly into its place in the stone aggregate may be found so that this objection will be met, or at least reduced to the minimum.

The third method, or the interposition of the bituminous mixture between the bottom and top courses, is best typified by what is known as the Gladwell system, and was described by Mr. Gladwell himself, Engineer and Surveyor to the Eton Rural District, England, in a paper presented to the Congress. After the foundation course, which is frequently the surface of an old road, has been brushed clean, a binding material composed of a bituminous cement mixed in proper proportio[ns] with screenings or chippings of fine, clean granite, q[uartz]ite, basalt or other hard stone is spread upon the s[ur]face. Upon this binding material is placed a layer of o[r]dinary broken stone, with no special preparation except [care]ful breaking and the elimination of dust and sma[ll] particles. A small amount of this binding material i[s] then lightly spread and brushed into the surface inter[stices] and the surface is rolled until the mass is fairly s[et]. A top dressing of hot, bituminous cement in the [pro]portion of about one quart to each square yard is fl[owed] over the surface, after which it is sprinkled with c[lean] chippings, or screenings, of the same character as tho[se] already described as forming the binding material, a[nd] the surface is then thoroughly rolled. The cost of this [treat]ment is given by the County Surveyor of Fife, Scot[land], as from 8 to 12 cts. per sq. yd. more than that of ordinary macadam.

The fourth, or mixing, method is perhaps more expensive than those already described, but it is probable that this method will be more likely than any of those yet mentioned to result in a road which is structurally and inherently dustless. What is known as Bitulithic pavement is of this type, but in Bitulithic special care is taken to grade the mineral matter as to size in order to produce a wearing surface of great density, and the cost of the pavement is too great to permit its use upon rural highways.

There has been laid in the Borough of Richmond a limited amount of what is called asphalt macadam, in which the mixing method has also been followed, and the results appear to be excellent.

The State Board of Public Roads of Rhode Island has built some miles of this type of highway [mixing method employed] with most satisfactory results. The methods used are given in a paper read [in 1908] before the American Society of Civil Engineers by Mr. A. H. Blanchard, who is in immediate charge of this work. The roads have been examined by the writer and were found to be in almost perfect condition and entirely free from dust. A number of these roads were built under contracts let for ordinary macadam, the State Board having agreed with the contractor to adopt the new method of construction, the contractor crediting the Board with the value of work not required, the Board furnishing the bituminous cement, and the extra work being paid for at cost plus 15%. The cost of tar macadam constructed by the mixing method was 12 cts. per sq. yd. greater than the contract price for ordinary macadam. The cost of a similar macadam in which the bituminous cement was composed of one-half tar and one-half asphalt was 13.3% greater than that of ordinary macadam, while the resulting road was especially satisfactory. A similar construction, in which tarvia was used as the bituminous cement, exceeded in cost the ordinary macadam by 15.1 cts. per sq. yd. This slight difference in cost was undoubtedly due to excellent management and careful oversight, and similar results would not be obtained except under equally careful supervision, but it has been demonstrated that at an increased cost within the reach of any community it is possible to secure a dustless road incomparably better adapted than is ordinary macadam to motor car traffic. Meanwhile it has been shown to be possible to overcome in a large degree the present dust nuisance by surface treatment consisting of the application of a binding material. This binder may be temporary only in its effects, such as light oils, tars and emulsions and solutions of various salts, having marked affinity for water, thereby keeping the road surface in a moist condition. The results obtained on the Boston parkways by the use of oil emulsions have already been noted. The binder may be of a more permanent character, such as heavy oils, tars and liquid asphalts, one application of which will, under moderate traffic, prevent the formation of dust to any great extent for an entire season. Such treatment should not be applied in a haphazard way, but should be the subject of careful investigation to determine the material and method of application best suited to the existing condition. An excellent paper upon this subject by Mr. Prevost Hubbard, Assistant Chemist, Office of Public Roads, has recently been issued by the United States Department of Agriculture as Bulletin No. 34 of the Public Roads Bureau. In it the author says:

> It is undoubtedly true that thousands of dollars are wasted annually in a repetition of experiments which have time and again proved costly mistakes. On the other hand, experiments which have given good results in some places have also proved failures when tried in different locations. It is necessary, therefore, not only that the experience of others be considered, but that some thought be given to the probable effect of local conditions upon the results which have in general been obtained. * * * Differences in composition and physical qualities (of the materials used) will often explain the fact that under otherwise similar conditions both good and bad results have been obtained. Discrepancies in results, however, are often obtained under varying conditions when the same material is employed in each case.

The highway system of France was briefly described as a preliminary to the discussion of the effect of motor cars upon roads. It will not be out of place at this point to refer briefly to the highway systems of other countries and the methods of their administration. Valuable information upon this subject is contained in a

report prepared for the Congress by Mr. W. Rees Jeffreys, Honorable Secretary of the Roads Improvement Association of Great Britain, and much of the data given below is taken from this report.

Highway Administration in Various Countries.

ENGLAND AND WALES.—The country roads are divided into main roads and district roads, but the reason for the classification with respect to any particular road is not always apparent. Prior to 1888 one-half the cost of main roads was borne by the State, but since that time there have been no fixed contributions by the general government, and the burden now falls upon the various counties and districts, and the demands made upon them are in many cases out of proportion to their resources. The methods of administration in England are in marked contrast to those in France. In the latter country there is a high degree of centralization, while in England and Wales there are nearly 1,900 separate boards and councils having jurisdiction over road maintenance. It is said that within fifteen miles of Charing Cross, London, there are ninety local road authorities acting independently of each other, and that a main road in twenty miles may pass through territory controlled by ten different highway authorities. Concerted action under such circumstances is manifestly impossible, and while during the last eighty years London and its traffic have increased a hundred fold, it is said that within that period no new main road has been built leading out of the city. There is no uniform organization for the carrying out of improvements. The labor is poorly paid, and in some of the rural districts employment on the highways is considered the last resort before the workhouse. Two years ago there were nearly 150,000 miles of roads in England and Wales, and the total annual expenditure for highway purposes, including installments on debt and interest, was nearly $78,000,000, but how much of this was expended on maintenance and how much on construction, is not clear. The organization and methods followed in the rest of Great Britain are so similar to those of England and Wales as to require no separate comment.

BELGIUM.—There are three grades of highways, known as state roads, provincial roads and conceded roads, all of which constitute a system of high roads called "La Grande Voirie," which are under the control of the Minister of Public Works, while the remaining roads are under the jurisdiction of the districts which they serve. The state roads constitute nearly 80% of the main roads of the kingdom, and the expense of construction and maintenance of them is borne by the State. The system of administration is highly centralized, as in France, and the work is entrusted to the "Corps des Ponts et Chaussees," a bureau of which is located in each of the nine provinces.

HOLLAND.—A Department of Roads exercises jurisdiction and control over the main highways. These are divided into three classes: imperial roads, made and maintained by the State; provincial roads, maintained by provincial taxation, although the State bears about one-third of the cost of new construction; and municipal roads, which are built and kept up by local authorities.

GERMANY.—The imperial government exercises little or no control over the highways and does not contribute to their expense. The roads are under the jurisdiction of the different states or kingdoms, although in Prussia the control is generally devolved upon provincial corporations, but the State contributes nearly $5,000,000 annually for the maintenance of the main roads. For the five years from 1900 to 1905 the average amount expended for construction and maintenance of highways in Prussia was about $8,500,000.

The road policy differs in the different states or kingdoms; for instance, in Saxony the government tries to have each locality pay for its own roads, although in exceptional cases the State will pay a large part and in some cases all of the cost of a new road for through traffic if the locality will furnish the land required. The burden of maintenance falls upon the district. In Baden the State pays four-sixths, the commune one-sixth, and the district the remaining sixth of the cost of building a main road, while the expense of its subsequent up-keep is met one-half by the State, one-fourth by the commune, and one-fourth by the district. The communal roads are built and kept in repair by the commune, and disputes as to the duty of a commune in this respect are settled by the courts.

AUSTRIA.—Highways are divided into state, provincial, district and municipal, or parish, roads. The administration is vested in and the expense imposed upon the State or the political division indicated by the above classification. There are in the road system of Austria, not including Hungary, some 71,500 miles of roads, of which 9,900 miles are state roads, 2,100 provincial, 37,000 district, and 22,500 municipal, or parish. The annual cost to the imperial government of keeping up the State roads in lower Austria is said to average about $130 per mile.

SWITZERLAND.—This country has an excellent highway system and a very efficient and economical administration, although entirely decentralized. The federal government assumes no duties and bears no part of the burden except that a contribution is made for certain roads which are considered international in character. The government can remonstrate with the authorities of a canton if they neglect their roads and can withhold contributions which might be made to that canton for international roads. The work generally is in charge of competent officials and well trained engineers. The limited authority of the central government is believed to impair the efficiency of the highway work.

ITALY.—The highways are classified in the same manner as in most other continental countries. The national roads are under the direction of a Department of Bridges and Roads and of the Corps of Royal Engineers attached to the Ministry of Public Works. Admission to this Engineer Corps is through competitive examination. The portions of national or provincial roads within the limits of cities or villages are maintained by the locality, but the central government or province pays to the local authority sums representing the cost of maintaining an equal length of road within the limits of the town. In 1904 the total expense of maintenance alone on Italian roads is said to have been $8,500,000.

SPAIN.—The roads are divided into first, second and third class, which are, respectively, built and maintained by the State, province or municipality. All plans of projected roads, after approval by the local authorities, are forwarded to the Minister of the Interior, who determines the class to which they shall be assigned. The Spanish road system consisted in 1905 of about 23,800 miles, and the total expenditure for construction and maintenance during that year was about $7,400,000.

Further data upon this subject is available, but it seems unnecessary to include it in this report. The system commonly in use is characterized by centralization of authority and responsibility, and, generally speaking, the greater the degree of centralization the more satisfactory the results, although Switzerland appears to be a conspicuous exception to this rule.

In Australia and Canada the system so familiar in this country prevails; that is, everything is left to the local authorities, the central government exercising no authority or control. In the United States the Department of Agriculture has established an Office of Public Roads, but its functions are chiefly educational and it might be called an intelligence office for the dissemination of information concerning highways. This office has a technical staff whose duty it is to build experimental roads and to direct road operations in communities where there is no proper organization for this purpose and where good roads are considered a valuable object lesson.

Pavements.

While the highways of the macadam type and the effect of the modern motor car upon them were the questions most discussed at the Congress, the general subject of city pavements was also considered and was the subject of a number of reports, and the observations which the writer was enabled to make are of at least equal interest to the City of New York. That the automobile has little, if any, effect upon the permanent city pavement was the general opinion of those who contributed to the papers and discussions. As stated by M. Mauhieu:

> On paved roadways the action of swift cars seems to have no effect on the wear of materials, and it is evidenced only by the production of a little dust.

One contributor, however, maintained that pavements of every description were seriously damaged by motor cars.

PARIS.—A brief description of the pavements of the city of Paris, the materials used, the character of their maintenance, and the cost of the service may be of interest.

On Jan. 1, 1908, the area of the different kinds of pavements in the city was as follows:

	Sq. yds.
Stone	6,726,100
Wood	2,464,900
Macadam	1,399,500
Asphalt	495,200
Total	11,085,700

The large area of stone pavements and the small amount of asphalt is surprising. The principal streets and boulevards are now paved with wood, which seems to be the popular pavement of the day in Paris. While the first asphalt to be laid upon a street in Paris was put down in 1855, the area of this kind of pavement had in twenty years from that date reached but 310,314 sq. yds., and it was only 495,200 sq. yds. at the beginning of the present year. The increase in the area of asphalt pavement has been but 60% in the past 33 years. During the last twelve years the increase was but 12%, and during the preceding 12-yr. period 20%. In striking contrast has been the development of wood pavement. Early attempts to use this material resulted in failure, but in 1881, with a new process of treatment, success was attained and so popular did this type of pavement become that at the beginning of the year 1908 the area of wood pavements in Paris had reached nearly 2,500,000 sq. yds.

The asphalt pavements are of the type known in America as rock asphalt, and though the kind of asphalt pavement in general use in this country was tried in Paris in 1900 with very satisfactory results, it has not come into general use. The cost of these pavements in Paris is from $2.87 to $3.12 per sq. yd., including a concrete foundation about 6 ins. in thickness. The contracts include no guarantee for current maintenance, the annual expense of which is very little, while the total estimated annual cost, including cleaning and a renewal of the asphalt surface, in about twelve years appears to be approximately 33 cts. per sq. yd.

The wood pavements are made for the most part of native pine from the Landes, a department of southwestern France, though some Baltic or other northern fir is used. The French engineers maintain that very hard native or foreign woods crush the foundation and give unsatisfactory results, and this conclusion appears to have been reached after a long investigation and considerable discussion as to the merits and availability of exotic woods of various kinds.

The paving blocks are made and creosoted at a plant owned by the city of Paris, which is said to be the largest of its kind in the world. The joints between the blocks are usually filled with cement grout. The cost of wood pavements is slightly less than those of asphalt, being from $2.70 to $3 per sq. yd., with a 6-in. concrete foundation. The cost of current maintenance is about 5 cts. per sq. yd. annually, while the total estimated cost of wood pavements, including cleaning at 12½ cts. and a renewal of the surface at the expiration of nine years, is given as 39 cts. per sq. yd.

Contracts call for no guarantee except to make good any defective workmanship during the first year, but this does not apply to defects in the blocks themselves. The life of a wood pavement in Paris varies from six to ten years, with an average of nine years. Where there is practically no traffic it will last for fifteen years, when it will rot and renewal becomes necessary. When the upper surface of the blocks becomes worn and uneven, they are taken up, the worn surface is trimmed off on the street by special gasolene or electrically driven machines, and the blocks are relaid with the trimmed surface down.

Fully 60% of the roadway pavements of Paris are of stone, a large proportion of them being sandstone. Paving blocks are purchased from the contractors or are quarried and made by the city. A large quarry, located in the forest of Marechaux, is extensively worked. The land upon which it is located belongs to the State, the city being the tenant and having developed the quarry.

The average cost of maintaining the stone pavements is given as 12 cts. per sq. yd. per annum, but this also undoubtedly includes not only actual repairs and maintenance, but an allowance for renewal, although there are no data at hand as to the frequency of such renewals. It does not, however, appear to include cleaning.

The area of macadam in Paris is decreasing, but is still considerable, amounting to nearly 1,400,000 sq. yds., of which about 430,000 sq. yds. are "tarred macadam," a small proportion of which was laid by the mixing method, but most of it is the result of surface treatment. In many quite important streets the central portion of the roadway is paved with macadam, while the sides are of stone block. The cost of maintaining macadam is said to be 38 cts. per sq. yd. annually, but this apparently includes not only cleaning and sprinkling, but the necessary periodic renewals of the surface.

The total expense of maintaining the public highways within the city in 1907 was about $2,425,000, while the cost of cleaning and sprinkling, not including macadam, was about $1,670,000.

The conspicuous feature of highway administration in the French capital is the constant investigation and experiment which is being carried on by trained experts. Analytical investigation of the composition of pavements, instituted by M. Buffet, Engineer of Roads and Bridges, in 1868, has developed into the present municipal laboratory, which has constantly extended the field of its tests and studies until today it is undoubtedly the finest in existence. Apparatus for testing resistance of paving materials to wear by friction was installed in 1868, and in 1873 there was added a machine for testing the resistance to abrasion of stone used in macadam roads. A special drilling machine is in use for testing the thickness and the degree of compression of asphalt pavements. This machine makes a round hole only 1⅝ ins. in diameter, which is simply and effectively refilled without mutilation of the pavement. Reference has already been made to the wood treating plant maintained by the city. Constant experiments are in progress to determine the life of this material and the forces which contribute to its destruction. In order that these problems may be most effectively studied, the laboratory makes use of an artificial "rotter," by means of which the action of these forces and elements can be intensified and their effects studied. In Paris, as elsewhere, the difficulty of maintaining pavements on streets containing surface railway tracks has been apparent, and there has been in use since 1905 a device for testing the flexure of rails under the traffic of the cars which they are designed to accommodate and that of vehicles which follow them. Appliances for sprinkling and cleaning the pavements have received much attention. This work is considered a part of street maintenance, although in the case of pavements other than macadam this expense is kept separately, as already indicated.

In cleaning and sprinkling smooth pavements, mechanical appliances are used wherever possible. A horse-drawn rubber sweeping machine consists of a rotary

broom sweeper, behind which are segments of rubber, the blades being parallel with the cylindrical broom and overlapping slightly, the effective length being equal to that of the broom. This machine is used after liberal sprinkling of the pavement or after rains. An automomile sweeper, with an 8 to 10-HP. motor, making 1,200 r. p. m. and equipped with electric lights, is now being tried out in one of the sections, while automobiles have been substituted for horses in hauling some of the rubber sweepers above described. A steam sprinkler operated by engines of 30 HP. is now in use, as is also an automobile sprinkling-sweeper operated by a motor of from 15 to 17 HP. The amount of sprinkling which is done appears excessive, and the pavements, while nearly always free from dust, are almost never dry. Sand is liberally used to prevent slipping, and the resulting surface is not pleasant. This excessive use of water may explain the short life of the wood pavements, which, as already stated, is from six to ten years.

The amounts expended upon the maintenance of the pavements of Paris may appear large, but it must be remembered that the figures include entire renewals of the surface when necessary, and there is no information available to determine the annual cost of ordinary repairs which might be compared with the expense of such work in this city. This emphasizes the danger of drawing conclusions from figures given in the reports of different cities or even those made by the different boroughs of this city. Data can be secured from published and apparently authoritative statements issued by different American cities which will appear to justify almost any statement or theory which may be advanced.

It is probable that the actual expense of maintaining the pavements of Paris is somewhat less than the amount expended by the City of New York if the cost of renewals were included in both cases, but that the work is more thoroughly done in Paris and other European cities will scarcely be disputed.

The area of pavements in this city, including all boroughs, as reported at the beginning of the present year, compared with those of Paris, is as follows:

	New York.	Paris.
Stone, square yards	8,380,800	6,726,100
Wood, square yards	287,800	2,464,900
Asphalt, square yards	13,901,500	495,200
Macadam, square yards	9,684,500	1,399,500
Total square yards	32,254,600	11,085,700

NEW YORK CITY.—The vastly greater area of pavements to be cared for in this city is surprising. If, instead of paying for repaving from the proceeds of the sale of bonds running for a term of years far exceeding the life of the pavement, as is our present practice, the entire cost of maintenance, including renewals, were included in the annual budget, the increase in the present tax burden would be considerable. The aggregate appropriations for repairs to and maintenance of pavements for all boroughs for the year 1908 was $2,966,376.50. The amount of corporate stock authorized for repaving was $3,000,000, which is less than usual, and the expense of street cleaning for the current year, exclusive of final disposition, appears to have been about $4,411,000, a total of about $10,380,000, for maintenance, cleaning and renewals. For a pavement area, approximately one-third as great, Paris expended during the year 1907 the sum of $4,095,000. On a basis of equivalent areas the expenditures of New York for the care of its streets are, therefore, some 13% less than those of Paris. If the allowance for repaving had been $3,800,000, as it was in 1907, the cost of the service in New York would have been about 6% less than that of Paris in proportion to area. Considering the lower cost of labor and the excellent organization the sums expended by Paris for this service are very large, but the French people evidently believe that it is worth what it costs.

OTHER EUROPEAN CITIES.—In Berlin and the German cities generally the pavements are very thoroughly laid and admirably maintained. Their first cost, even with cheaper labor and very efficient organization, is about the same as in this country and in some cases higher. In Leipzig, for instance, the cost of asphalt paving is about $2.50 a sq. yd. for German rock asphalt and $3 where the French asphalts are used, both these prices including the concrete foundation.

Edinburgh is conspicuous for its admirable pavements, especially those of granite block, which is kept in nearly perfect condition both with respect to surface and cleaning. The topography of Edinburgh requires the use of many retaining walls and steps, and the thoroughly good quality of the masonry and the care with which it is maintained impress the most casual observer.

The London streets carry an enormous traffic, and the excellence of the pavements, whether of stone, wood or asphalt, is conspicuous. Openings in the pavements are rarely seen, as when such openings are made they are repaired promptly and skillfully. It is probable that the number of pavement openings in European cities is far less than in New York, as the use of electric light, telephone and other public utilities whose structures occupy the streets is much less general than in American cities. Wood block appears to be the popular pavement in London, and the manner in which it sustains the enormous traffic of such streets as The Strand is certainly remarkable. The wood pavement at the lower end of this thoroughfare was found to be in excellent condition, though it had been in use for more than six years. Mr. J. W. Bradley, the City Engineer of Westminster, which comprises that part of London where the traffic is heaviest, informed me that these blocks were 7 ins. deep and were laid upon the best possible concrete foundation. Wood blocks 4 ins. or less in depth, as laid on Broadway, in this city, would not be used in England under any circumstances. In the West Riding of Yorkshire the standard blocks are 6 ins. deep, while Mr. Robert Philipps, Consulting Surveyor to the Gloucester County Council, in a paper presented to the Congress, states that wood blocks as well as granite blocks are generally 9 ins. in depth on a concrete foundation of 6 ins. Such extreme depth appears to be unnecessary, but I am convinced that in this city a serious mistake has been made by using wood blocks of too little depth. The wood used for paving in England is for the most part Baltic fir or other soft wood, little of the Australian or other hard woods being employed. In London many of the heavy loads are hauled through the streets at night by the use of traction engines or auto trucks. The use of traction engines on the rural highways of Great Britain is increasing very rapidly. Mr. W. J. Taylor, County Surveyor of Hampshire, says that there are now about 8,500 such engines in use on the highways of England and Wales, or about one to every 1¾ miles of main road. These engines, while slow moving, are heavy, and haul wagons with correspondingly heavy loads. This kind of traffic has necessitated the provision of strong surfaces and foundations, and it has been predicted that it will be necessary to build macadam roads which are likely to be subjected to exceptionally heavy traffic with a substantial concrete foundation. This opinion was unqualifiedly expressed by Mr. P. W. Henry, of this city, one of the American delegates to the Congress, in a paper which he presented.

I was unable to secure information as to the expense of maintaining the pavements of London, but their first cost appeared to be fully as great as in this country. This, as already intimated, appears to be true of European cities generally, but it must be admitted that the work is more thoroughly done. The chief aim appears to be to build as well as possible (not that economy is overlooked). Economy of administration and management, and especially the economy that consists in selecting the material best adapted to the results desired, is the rule, not the exception, but there is no economy for the mere sake of cheapness. A public officer is commended for conducting thorough investigations to determine the best materials and methods. If he can show that he has produced a superior and more lasting pavement, and if at the same time its cost is not increased, but has been possibly reduced, he is entitled to and receives due credit, but the chief object in view is the improvement in quality, while reduction in first cost is almost considered incidental.

Experts and Efficient General Administration: With Local Applications.

From what has already been said it will be seen that the work of constructing the roads and pavements of Paris and other European cities is in the hands generally of trained experts. The materials and methods of using them are the subject of intelligent and painstaking investigation, and a careful record is made of the results obtained, not only in the laboratory, but on the street. Experience gained in one division of public works is promptly availed of in others, and new and successful methods employed in one city are promptly adopted by other municipalities. Nearly all of the European cities send some member of their technical staff each year to investigate what is being done in other countries and cities, in order that they may have the benefit of the latest knowledge and the most improved methods. In this respect we are far behind them, and for this fact the cumbersome organization, or rather a lack of organization, in our highway work is largely responsible.

The Board of Estimate and Apportionment [New York City] has lately created two committees, which are to report, respectively, upon methods of keeping cost data in connection with highway and sewer maintenance. These committees will soon submit reports, with recommendations for the adoption of methods which will at least show where and how appropriations are expended, and whether they are well used or largely wasted. But more than this is required; more careful investigation as to the special fitness of materials for the purpose for which they are to be used, and standard specifications to insure the furnishing of materials of the desired quality; a well equipped laboratory to make not only the tests named in the specifications, but to conduct experiments which will lead to the adoption of methods and materials better than those in common use, careful investigation of the best means of reducing, if not entirely avoiding, the dust nuisance on our macadam roads, and the best and most economical methods of securing dustless roads for new construction and resurfacing; a thorough reorganization of the force employed by the city, so that it shall be better balanced, that each man must do a fair day's work or get out, and t[he] amount of work done by each unit in the orga[n]ization may be increased, while the size of the payroll ma[y] be diminished; the keeping of careful and int[e]lligible records to indicate the initial cost, the expense of maintenance and the effective life of all pavements [as] are laid. If these policies could be inaugurated a[s] adhered to the highway work of the city might be put [on] a sound and economical basis. To accomplish th[ese] results with a separate Highway Bureau in each bo[rough], and with no cooperation between them, would be almost nigh impossible, and with the duplication of work [that] now exists the economies desired could not be effect[ed].

But what can be done at once? Two of the boroughs have laboratories connected with their Highway Bu[reaus]. At least one of the other boroughs sends its samples for examination and analysis to outside laboratories, [but] no one attached to a department or bureau having no [juris]diction over highway work. So far as I know, no [use] of the results obtained in any one of these laboratories is placed at the disposal of the others. Why should not one central laboratory, thoroughly equipped, make all the tests, analyses and examinations required by all the departments? The head of such a testing bureau should be capable of inaugurating investigations which would be of benefit to all departments and officers charged with construction or maintenance work, and not content himself with bare reports upon samples submitted to him. He would be conversant with what is going on in other cities and countries, and could point out the directions in which economies could be effected and better results obtained. For example, in this one question of dust prevention on our macadam roads he should and would know what treatment had been shown to be most economical and effective for the special conditions which exist. He would prepare suitable specifications for the purchase of such material in the quantity needed, would advise as to the time and manner of its application, and keep an intelligent record of the cost and results. Instead of groping and floundering in the dark, instead of mistakes made in one borough or department and repeated in another, without knowledge of failures already experienced and perhaps carefully concealed, each city officer would have at his disposal the accumulated experience of all the others. The successes and the failures of other departments, other cities, other countries would be available for him to follow or avoid. The advantages of such a laboratory for examination and research seem quite evident. It may be said that results could not be obtained as promptly from a central office as from one located in the department which it specially serves, and that the very object of its establishment would be defeated in that unsuitable material might have been used before its defects had been disclosed. Such an objection does not seem tenable. The few minutes or even hours lost in sending samples to a central testing laboratory would be more than balanced by the better facilities for quick work and the presumably more valuable results due to standard and uniform practice.

In my judgment, this would be an excellent beginning in carrying out the policies herein briefly outlined, and it could be made at once. Meanwhile, I believe that the two committees already created by the Board to consider cost data in connection with highway and sewer work will be able to present a plan which will prepare the way for other improvements which have been suggested.

BOILER-ROOM EFFICIENCY RAISED BY COMPETITION.—The United States Navy has found that a notable economy in coal consumption may be secured by establishing competition between the boiler-room crews of different vessels. The Chief of the Bureau of Equipment, in his report for 1908, says, in speaking of the cruise of war vessels around the world, still in progress:

> Early in the cruise the commander-in-chief inaugurated a system of competitive firing between the various ships. The spirit of competition and the desire to excel caused keen rivalry between the engineer forces on the different vessels of the fleet, with the result that the men have put forth their best efforts in order to reduce the coal consumption, and it is gratifying to observe that the average total consumption has been reduced 20%, which means a great saving in money to the Government as well as improving the efficiency of the ships.

SULPHUR ELIMINATION IN THE CUPOLA was investigated recently by O. Johansen of Brebach, Germany, to determine the proportion of sulphur carried away by the gases. By the actual analysis of discharge gases he found that on the average each cubic meter of gas (measure at freezing-point and standard barometer) contained 1 gram of sulphur, i. e., 1 cu. ft. carried 0.000062 lb. sulphur. With coke of 1¼% sulphur, about one-half the total sulphur would go off in the gas, leaving only one-half to be absorbed by the iron and slag. In the same experiment it developed that the slag carried away only one-third as much sulphur as the gases. The cupola on which the tests were made was 39 ins. in diameter and 16 ft. high. The tests are reported at considerable length in "Stahl und Eisen" of Nov. 25, 1908.

The New Bridge Crossing the Mississippi River at Clinton, Ia.; Chicago & Northwestern Ry.

By F. H. BAINBRIDGE.*

One of the important railway bridges crossing the Mississippi River is that of the Chicago & Northwestern Ry. between Fulton, Ill., and Clinton, Ia. The first bridge at this point was completed in 1864, and after having its spans strengthened and renewed at different times it has been superseded by an entirely new structure parallel with it. This bridge is now completed, with the exception of the draw span. The bridge is on the main line of the Chicago & Northwestern Ry. between Chicago and Omaha. It is used also by the Chicago, Rock Island & Pacific Ry. for freight transfer, and by the Chicago, Burlington & Quincy Ry. for its lines from Clinton, Ia., to Mendota, Ill., and to Savanna, Ill.

The design and construction of the new bridge have been under the direction of Mr. E. C. Carter, M. Am. Soc. C. E., Chief Engineer of the Chicago & Northwestern Ry.; Mr. W. H. Finley, M. Am Soc C. E., Assistant Chief Engineer, and Mr. I. F. Stern, Engineer of Bridges. Mr. H. M. Spahr is assistant engineer on the work. The writer is Resident Engineer in charge of the construction of the bridge.

*Resident Engineer, Chicago & Northwestern Ry., Clinton, Iowa.

HISTORICAL REVIEW.—The Chicago & Galena Union Ry., the nucleus about which the present great Chicago & Northwestern Ry. system has been built, was finished as far as Fulton, Ill. (opposite Lyons, Ia.), on the Mississippi River, in 1855. In 1858, the Chicago, Iowa & Nebraska Ry. was laid from Clinton, Ia. (about 2½ miles downstream from Lyons) westward to Lisbon, Ia., a distance of 66 miles. It was the intention of the management of the Chicago & Galena Union Ry. at that time to build a high-level bridge across the Mississippi River between Lyons, Ia., and Fulton, Ill., or about 2½ miles upstream from the site of the present structure. Difficulties in securing right of way in the town of Lyons delayed the matter, and finally (with other causes mentioned below) caused the abandonment of this project. This was unfortunate, as the Lyons site is far better than the one chosen.

In 1858 the management of the Chicago, Iowa & Nebraska Ry., being interested in the development of the present town of Clinton, Ia., started the construction of a bridge at Clinton from the left or east bank of the river. This was finished in 1859, as far as Little Rock island (an outcrop of rock well above high water in the river and forming the eastern boundary of the west channel at the crossing). It connected with the Chicago & Galena Union Ry. by a line along the east bank of the river to Fulton, Ill. Between Little Rock island and the Iowa shore a car-ferry was operated by the Chicago, Iowa & Nebraska Ry. This railway was leased to the Chicago & Galena Union Ry. in 1862. In 1864 the west channel was bridged, completing not only the second bridge across the Mississippi River, but also one of the most important bridges of its day.

It is of interest to note that Mr. W. D. Walden, Foreman of Carpenter Work on the first construction in the east channel in 1858-59, and on the west channel in 1864, is still in active work for the Chicago & Northwestern Ry., as superintendent having in charge the maintenance of the Clinton Bridge.

The crossing at Lyons, at first contemplated (as noted above), was over a single channel 1,450 ft. in width. This had high bluffs on each side, and a rock foundation not far below low water, and was an ideal location for a high level bridge. This site is now occupied by a highway bridge between Fulton and Lyons, built in 1891.

The Clinton crossing has a total length of 4,200 ft., and is broken by two islands; Little Rock island (above high water), over which the track is carried on an earth embankment; and Willow island (below high water), which is spanned with trusses.

The profile and elevation (A) in Fig. 1 represents the first bridge, as built from 1858 to 1864. The east channel spans were McCallum trusses built entirely of wood, except for bolts and for diagonal rods in the third and fourth panels at each end of each truss. The fixed spans in the west channel were Howe truss spans. The draw span was of the Bollman pattern. The top chords were composed of two 12-in. channels with 12½-in. cover plates top and bottom. The bottom chords had two 6-in. channels with 12-in. cover plates top and bottom. The center posts, turntable and end posts were of cast iron.

This bridge was designed for a moving load of 2,500 lbs. per lin. ft. At the time of the building of the east channel spans, the heaviest engine in service on the Chicago & Galena Union Ry. weighed (with tender) 28 tons. The heaviest engines operated over the present bridge weigh (with tender) 140 tons. The new bridge is designed for Cooper's E-50 loading, the engines for which weigh (with tender) 177.5 tons.

All the east channel piers were of cut stone masonry on a foundation of piling capped with a wooden grillage. The west channel abutments and piers were all of cut stone masonry, and are still standing in good condition. The abutments were founded on rock. The center pier and the two rest piers of the draw were founded on wooden cribs loaded with stone and sunk to the river bed.* The remaining west channel pier was on piling capped with a wooden grillage.

The McCallum trusses were the first to require renewal. The easterly McCallum truss span was rebuilt as a 200-ft. pin-connected Pratt truss in 1869, and this in turn was replaced by heavier Pratt pin-connected spans in 1881 and 1898. The remaining McCallum spans were renewed with pin-connected Pratt spans 150 ft. in length in 1870. These latter were replaced with heavier spans of the same type from 1882 to 1886. The Pratt truss spans were in service until the opening of the new east channel spans in August 1908.

The draw span was renewed in 1887. The Howe trusses of the west channel were replaced first with pin-connected Pratt trusses in 1875, and again with heavier spans of the same type in 1898. The upper and lower treads of the turntable of the draw span, and also the end lift mechanism, were replaced in 1901. Many minor repairs for strengthening the floor system and connections became necessary, both in the east and west channel spans built prior to 1898, owing to a traffic constantly increasing in frequency and in concentration of weight.

The draw span was replaced in a novel manner. The new span was erected (in the up and downstream position) on the protection pier, the new turntable being put in and connected to the old span. The new span was coupled up to the center tower of the old span and when everything was in readiness to transfer traffic, the star-shaped combination of the new and old spans

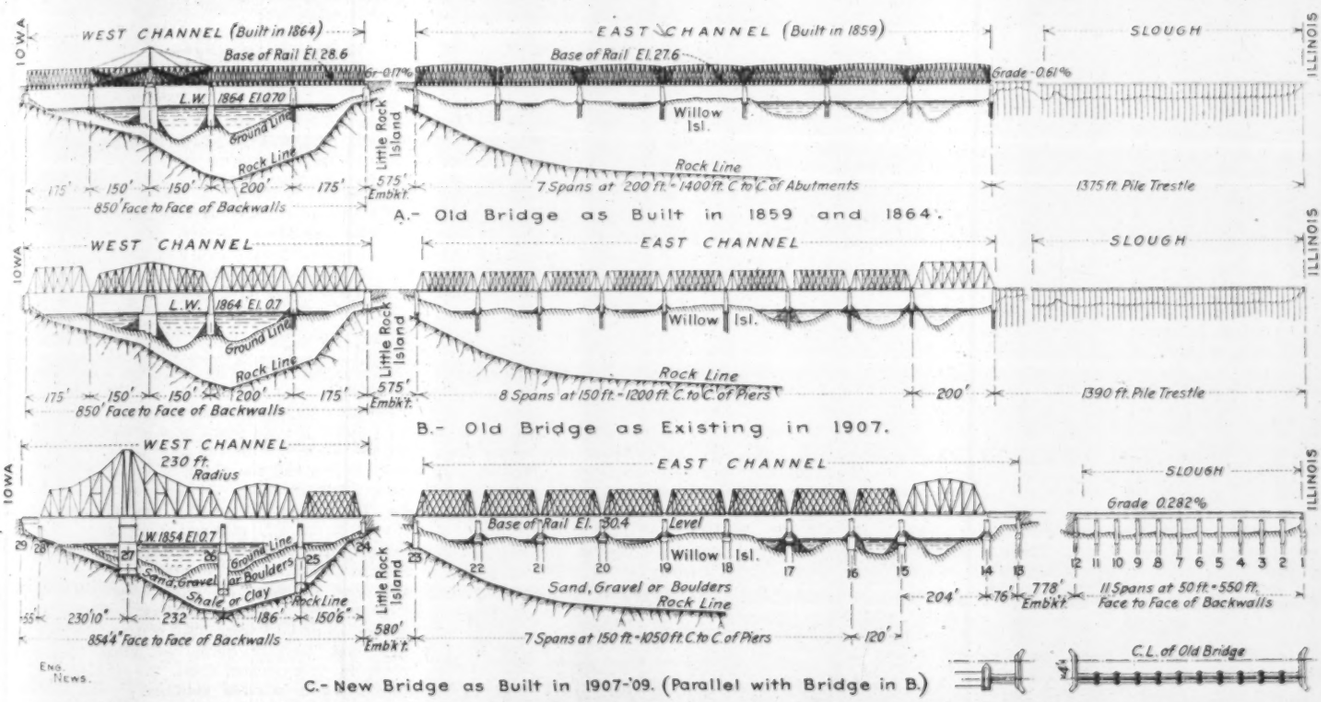

IOWA
WEST CHANNEL (Built in 1864)
Base of Rail El. 28.6
Gr. 0.17%
L.W. 1864 El. 0.70
Ground Line
Rock Line
175' 150' 150' 200' 175'
850' Face to Face of Backwalls
Little Rock Island
575' Embk't.
EAST CHANNEL (Built in 1859)
Base of Rail El. 27.6
Grade 0.61%
Willow Isl.
Rock Line
7 Spans at 200 ft. = 1400 ft. C. to C. of Abutments
SLOUGH
ILLINOIS
1375 ft. Pile Trestle
A.- Old Bridge as Built in 1859 and 1864.
WEST CHANNEL
EAST CHANNEL
SLOUGH
L.W. 1864 El. 0.7
Ground Line
Rock Line
175' 150' 150' 200' 175'
850' Face to Face of Backwalls
Willow Isl.
Rock Line
8 Spans at 150 ft. = 1200 ft. C. to C. of Piers
200'
1390 ft. Pile Trestle
B.- Old Bridge as Existing in 1907.
WEST CHANNEL
230 ft. Radius
EAST CHANNEL
SLOUGH
Grade 0.282%
L.W. 1854 El. 0.7
Ground Line
Sand, Gravel or Boulders
Shale or Clay
Rock Line
55' 230'10" 232' 186' 150'6"
854'4" Face to Face of Backwalls
Base of Rail El. 30.4 Level
Willow Isl.
Sand, Gravel or Boulders
Rock Line
204' 76' 778' Embk't.
11 Spans at 50 ft. = 550 ft. Face to Face of Backwalls
580' Embk't.
7 Spans at 150 ft. = 1050 ft. C. to C. of Piers
120'
C.L. of Old Bridge
C.- New Bridge as Built in 1907-'09. (Parallel with Bridge in B.)
ENG. NEWS.

FIG. 1. ELEVATIONS OF THE OLD AND NEW BRIDGES OVER THE MISSISSIPPI RIVER BETWEEN FULTON, ILL., AND CLINTON, IA.; CHICAGO & NORTHWESTERN RY.

*Pieces of old iron strap rails were used for the iron-work required in the construction of this cribbing, in 1863. Some of these pieces were recovered in 1908 and showed no signs of deterioration. This was noted in our issue of Aug. 6, 1908.—Ed. Eng. News.

was turned through one-fourth of a revolution. This brought the old span into the open position, and the old span was then taken down while supported by the protection pier. This work was done by Mr. E. C. Carter (now Chief Engineer of the Chicago & Northwestern Ry.), representing the Detroit Bridge & Iron Works.

At (B) in Fig. 1 is shown the old bridge as it exists at the present time. The intention is to remove both spans and piers in the west channel and to retain the east channel spans in service as a third track, the center line of the new bridge being parallel to and 40 ft. downstream from that of the old structure. (See Fig. 3.)

The New Bridge.

A constantly increasing traffic amounting at times to 150 or more train movements per 24 hours, as well as the condition of the old structure requiring a reduction in train speed, brought about the consideration of a rebuilding of the bridge as early as the year 1900. Surveys and borings for a new double-track structure were made in 1901. An act of Congress approved Feb. 6, 1907, authorized the reconstruction of the bridge, and plans were approved by the Secretary of War on May 4, 1907. A formal order authorizing the necessary expenditures was issued by the Vice-President in charge of Construction, Chicago & Northwestern Ry., March 21, 1907.

The contract for the construction of the entire substructure was entered into with the Foundation Co., of New York, on May 18, 1907. The contract for furnishing and erecting the east channel and slough spans was entered into with the Wisconsin Bridge & Iron Co., of Milwaukee, Wis., May 21, 1907. The contract for furnishing and erecting the west channel spans was made with the Pennsylvania Steel Co., of Steelton, Pa., on Feb. 3, 1908. This company sub-let the work of erection to the Missouri Valley Bridge & Iron Co., of Leavenworth, Kan.

The map, Fig. 3, shows the relative positions of the old and new structures and the adjoining highway bridge. The profile and elevation (C) in Fig. 1 show the outline of this bridge. In the following description the piers and spans will be designated by the numbers shown on the cut. The elevations shown on the plans are referred to the U. S. Engineers' datum plane; the extreme observed low water elevation is 0.7 ft. above this plane, and extreme high water elevation 21 ft. above this plane. For the purposes of description the crossing naturally divides itself into five parts from east to west, as follows: (1) the slough spans; (2) the easterly embankment; (3) the east channel spans; (4) the Little Rock island embankment; (5) the west channel spans.

THE SLOUGH SPANS.—The total length between the backwalls of the abutments is 550 ft., divided into 11 double-track plate-girder deck spans of about 50 ft. each. The abutments, Nos. 1 and 12, are of dimension stone (red rock sand stone from Ablemans, Wis.) laid on concrete footings supported directly by piles. Piers Nos. 2 to 11, inclusive, are pairs of Cushing cylinder piers with 15 to 18 piles to each cylinder. The piles averaged about 28 ft. long and were driven to an average elevation of —1.3. The average elevation of the bottom of the cylinders is about —10.67, and that of the concrete in the cylinders —3.67. The cylinders are 8 ft. in diameter and are constructed of ⅜-in. plates. Each is capped with an 18-in. coping of Ablemans (Wis.) white sandstone. (See Fig. 9.)

The bed of the slough at the surface is muck a few feet in depth, below which is sand of unknown depth. There is little or no flow in the slough below a water stage of —10, and the situation is such that neither ice nor drift can be carried through it, owing to the protection of standing timber at the head of slough. On the old bridge, a pile trestle has been maintained here for 50 years.

To facilitate construction, a temporary pile trestle of 16-ft. spans, four piles to a bent, was built on the center line of the bridge. The piles in the cylinder piers were driven from leads suspended from a derrick car. The cylinders were forced down by loading them and by jetting with water around the edges.

Work on the temporary trestle was started July 10, 1907, and the cylinder piers were finished complete by Jan. 28, 1908. The superstructure of plate girders and cross girders was erected with a derrick car. This latter work started June 5, 1908, and riveting was finished July 20, 1908. The quantities in this section of the work are as follows: Piles, 633; cut stone, 1,109 cu. yds.; concrete, 1,335 cu. yds.; steel in cylinder piers, 162.35 tons; weight of superstructure, 569.4 tons.

THE RIVER EMBANKMENTS.—Between the east channel and the slough is alluvial ground averaging about 10 ft. above low water, and well covered with brush and full grown timber. The old bridge crossed this by a pile trestle. For the new bridge, abutments were built at the west end of the slough span (No. 12), and the east end of the east channel span (No. 13), and the intervening space was covered with a sand embankment made by a hydraulic dredge working in the east channel. The average height of the embankment was 18 ft. and the total amount of fill 40,700 cu. yds.

The embankment across Little Rock island was made in a similar manner, and contains about 10,100 cu. yds.

The East Channel Spans.

SUBSTRUCTURE.—All the piers and abutments are built of dimension stone masonry. The abutments (Nos. 13 and 23) are of red-rock sandstone from Ablemans, Wis. Piers Nos. 20, 21 and 22 are of Kettle River sandstone, and the balance of the piers are of Ablemans white rock sandstone. The last is an extremely hard siliceous sandstone, nearly pure white in color, and is probably as tough and durable a stone as can be found anywhere.

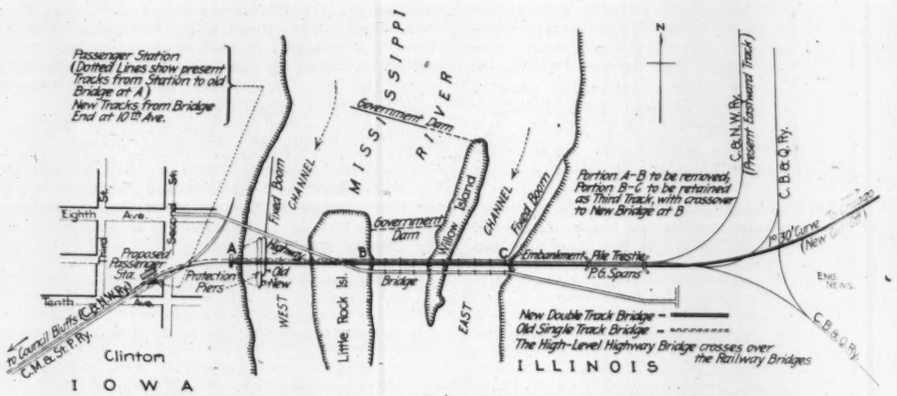


FIG. 2. MAP SHOWING THE POSITION AND CONNECTIONS OF THE CLINTON BRIDGE OVER THE MISSISSIPPI RIVER; CHICAGO & NORTHWESTERN RY.

All these piers and abutments are on piling, except No. 23, which was carried to rock. The profile, Fig. 3, is somewhat misleading as to ground line, that shown being the center line profile. The new piers were in all cases built opposite, or nearly opposite the old piers. As a consequence the ground level due to the rip-rap piled about the old piers, was above low water at the upstream end of the new piers, while at the downstream end the depth of water was in many cases 20 ft. or more. Where the ground surface over the area of the footing was within a reasonable distance the concrete footing was laid directly on the piling. Where the water was deep on the downstream side, the piers were rip-rapped inside and outside the piling and the masonry was laid on a wooden grillage. Piers Nos. 13, 14, 16, 18 and 19 were built with a concrete footing, laid directly upon the piles. The other piers in this section have the concrete footing laid upon a wooden grillage.

Considerable difficulty was experienced during the building of the new piers by the settlement of the adjoining piers of the old bridge. As it was absolutely essential that traffic should be uninterrupted, the methods followed in rebuilding the new piers were such as it was believed would disturb the old piers as little as possible. All these piers except No. 17 were built in open cofferdams. Some years ago, an iron span from the adjoining highway bridge was blown over in a heavy wind storm, falling on the site upon which this pier was built. As it was impossible to drive steel sheet piling without removing the old highway span, timber piles were cut off under water with a rotary saw, and an open caisson was landed on them.

Single lines of Wakefield sheet piling were used in the cofferdams of Nos. 13 and 18; single rows of steel sheet piling (United States pattern) in Nos. 19 and 23, and double rows of the same steel sheet piling in the balance of the piers. Where the ground level was above the water line, or where it could be brought above with filling, single rows of sheeting were used. Where the water was deep, double rows were put in, with a puddled filling between them.

In constructing Pier No. 16, the adjoining pier of the old bridge settled to such an extent that extreme precautions were necessary. In consequence, piles were cut off with the rotary

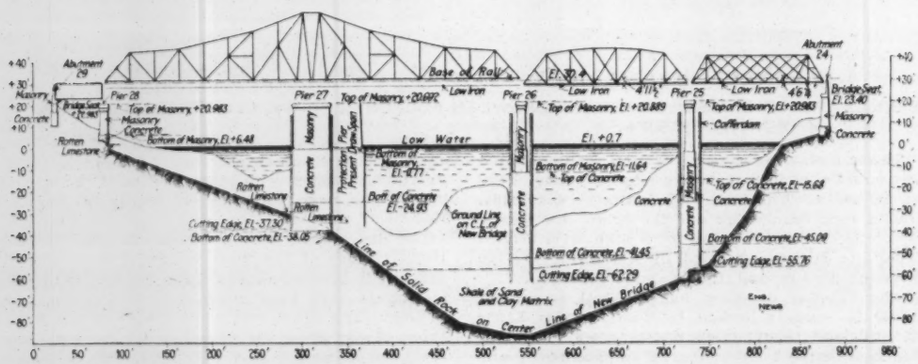

Abutment 24
Base of Rail
Low Iron
Pier 26
Pier 25
Pier 27
Pier 28
Abutment 29
Top of Masonry, +20.983
Top of Masonry, +20.889
Top of Masonry, +20.903
Bridge Seat, El. 23.40
Masonry
Concrete
Rotten Limestone
Low Water
El. +0.7
Bottom of Masonry, El. +6.48
Bottom of Masonry, El. -4.77
Bottom of Masonry, El. -11.64
Top of Concrete
Bott. of Concrete, El. -24.93
Ground Line on C.L. of New Bridge
Cofferdam
Top of Concrete, El. -15.68
Bottom of Concrete, El. -45.09
Cutting Edge, El. -55.76
Cutting Edge, El. -37.50
Bottom of Concrete, El. -38.05
Bottom of Concrete, El. -41.45
Cutting Edge, El. -62.29
Shale of Sand and Clay Matrix
Line of Solid Rock on Center Line of New Bridge
Eng. News
0' 50' 100' 150' 200' 250' 300' 350' 400' 450' 500' 550' 600' 650' 700' 750' 800' 850' 900' 950'

FIG. 3. PROFILE AND ELEVATION OF THE WEST CHANNEL PORTION OF THE NEW CLINTON BRIDGE; CHICAGO & NORTHWESTERN RY.

saw at [illegible] ft. below low water and part of the concrete [illegible]ting was deposited through the water be[illegible] pumping out the cofferdam. This avoided [illegible] danger of an inflow of material from around [illegible] adjoining pier.

The [illegible]antities in this section of the work are as foll[illegible]: Piles, 1,750; grillage, 140,700 ft. B. M.; con[illegible]ete, 2,200 cu. yds.; cut stone masonry, 4,400 c[illegible] yds.; rip-rap, 1,500 cu. yds.

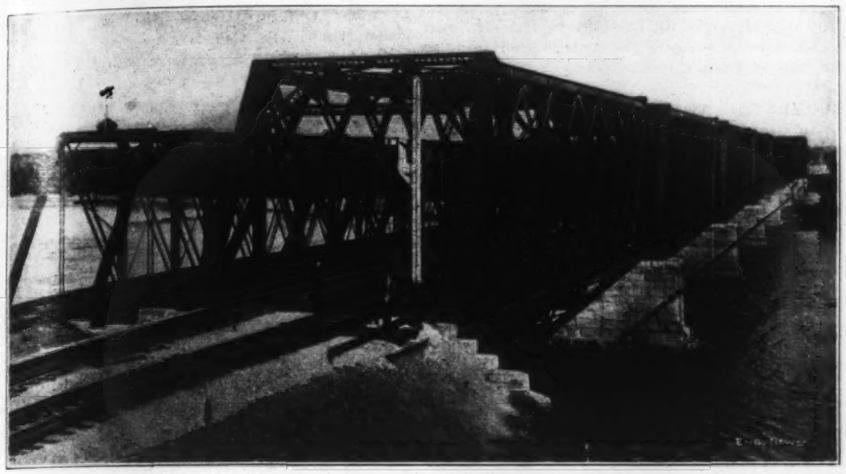


FIG. 4. THE EAST CHANNEL PORTION OF THE NEW CLINTON BRIDGE; CHICAGO & NORTH-WESTERN RY.

(The view is looking east. On the left is the old single-track bridge. There are eight riveted lattice truss spans and a Pratt truss span.)

A temporary pile trestle with 16-ft. spans and carrying two tracks, was built with its center line on the center line of the permanent bridge for handling material. It had five piles to a bent, and caps 28 ft. long. A stiff-leg derrick was set up on piling at each pier, but much of the material was handled with a Brown hoist crane or a derrick car.

Work on this section of the substructure was started July 3, 1907, and finished March 14, 1908.

SUPERSTRUCTURE. — As previously intimated, the lengths of the spans were fixed by the positions of the old piers. Beginning at the east end and running west, they are as follows: 74-ft. deck plate girder; through riveted Pratt truss span, 202 ft. 3¼ ins.; through riveted lattice truss span, 115 ft. 7¾ ins.; and seven through riveted lattice truss spans of 146 ft. 5½ ins. There were no unusual features in these spans except that the Pratt truss is longer than is customary practice for a riveted span. Fig. 4 is a general view of the east channel spans, showing the riveted lattice trusses. At the left is the old single-track bridge. Fig. 5 shows the Pratt truss span (202 ft. 3½ ins.) over the "raft channel." Fig. 6 is an end view, and gives a good idea of the massive construction of the trusses. It shows also the deck construction, which is described later. This view is looking west. On the right is the old single-track railway bridge, while on the left is the high-level highway bridge.

The method of erection was unusual. The falsework put in for constructing the substructure was used for the erection of the superstructure without change. The stringers on the falsework were at the proper level, so that the floorbeams and stringers of the iron span could be blocked on them at their proper elevation. Floorbeams and stringers were first laid complete for a span on the falsework. As this falsework was not of sufficient width to support the trusses directly, they were erected in position supported by the floorbeams. All steel was handled with a derrick car, no traveler being used. Opposite members in the two trusses were put up consecutively, so as to keep the trusses nearly balanced in weight at all times.

The work of erection started Jan. 27, 1908, and was finished and falsework removed July 14, 1908. Ice broke up in the river at this point on March 7, 1908, and the falsework was slightly damaged. The movement was confined almost entirely to the west channel, so that the falsework escaped serious injury. The weight of the superstructure of this section of the bridge is 3,214 tons.

The West Channel Spans.

This channel is much the more important. Though only 600 ft. wide at low water and 850 ft. wide at high water, it is much the deeper of the two channels and carries the principal thalweg of the stream. Owing to the strong set of the current from the left towards the right bank at high stages of water, the east channel (span 14-15) is used for passing timber and log rafts at high stages of water. Steamers use the west channel exclusively, and rafts use it at low stages of water.

The draw span protection pier is a wooden crib filled with rip-rap. Upstream and in line with this extends a floating sheer-boom to a point on the right bank about 1,000 ft. above the bridge. This boom is removed to a safe position at the close of navigation. A similar construction will be used for the new bridge.

Although no difficulty had been experienced with the west channel piers of the old bridge, (having foundations as previously described), it was decided to found the new piers on rock or other firm strata below the reach of scour, thus providing the best possible waterway and one least liable to bring about a serious ice gorge.

It should be noted that conditions at the present time are essentially different from those at the time when the old west channel piers were built. In 1891, dams of rip-rap and brush extending from 2 ft. to 3 ft. above low water were built by the U. S. Engineers between the heads of Little Rock and Willow islands. This was with a view to increasing the flow in the west channel and scouring away bars formed below the contracted channel at the crossing, caused by the interposition of the two islands and the consequent divided flow which obtained below the islands. At the present time, therefore, there is far greater probability of scour around the piers than previous to the construction of these dams.

SUBSTRUCTURE.—Borings made with a churn drill in 1901 located a supposed rock line as shown by the dotted line in the profile of the west channel Fig. 3. Experience with the first caisson sunk showed the ledge rock to be far below what was supposed, and a correct rock line was located by a new set of borings made in April and May, 1908. These borings were described by the writer in "Mine and Quarry" for October, 1908. [See end of article.—Ed. Eng. News.]

Piers Nos. 24, 28 and 29 are founded on a soft, porous buff limestone belonging to the Gower stage of the Niagara series of rocks. Piers Nos. 25 and 27 are founded in a hard compact, white limestone belonging to the Delaware stage of the Niagara series. Pier. No. 26 is founded in a peculiar strata consisting of sand and clay well indurated. This deposit (though recent) is pre-glacial. It can be traced to a period during which the carboniferous rocks, which formerly covered this section, were degraded. At that time the Mississippi River at this point was a lake of many miles in width and of great depth, similar to the existing Lake Pepin. The high ground to the west of Clinton shows evidence of having been an island in this lake. The clay is a water deposit due to the degradation of the carboniferous shales and the sand is wind blown from the neighboring carboniferous sandstones. The coloring matter in the upper strata of the clay is black (from degraded coal measures), and in the lower strata red (from degraded iron ore beds.)

FIG. 5. PRATT TRUSS SPAN OVER THE RAFT CHANNEL IN THE EAST CHANNEL PORTION OF THE CLINTON BRIDGE (SPAN, 202 FT. 3 1-4 INS.).

Piers Nos. 24, 28 and 29 were built in open cofferdams made with single rows of the United States steel sheet piling.

Piers Nos. 25, 26 and 27 were put down by the pneumatic process. The greatest air pressure used was 34 lbs., in pier No. 26. The power-house was located on Little Rock island, just south of the crossing and the air was led by pipes over the temporary trestle built as a construction trestle for the piers and as falsework for the superstructure. After a number of unsuccessful attempts to maintain an air pipe on the bottom of the river, air was carried to pier No. 27 by a pipe laid over the adjoining highway bridge, which is a high level crossing. This furnished an uninterrupted connection.

Pier No. 25 was sunk during January-April, 1908. Pier No. 27, being the one most protected from the river current at high water, was put down in May to August. Pier No. 26, being the most exposed to the current during the low water period, was put down during September-November.

The caissons were constructed on ways on the west river bank, launched in the water and towed to place. At pier No. 26, as the new pier was put down on one side through the rip-rap of the old pier, considerable dredging was necessary to level the river bed. As the east side of the new pier No. 27 was sunk through the crib of the old protection pier, the west side of the new pier was supported on pillars made of bags filled with sand, to allow sufficient weight to be added to overcome the effect of the necessary air pressure and to carry on sinking.

Previous to sinking piers Nos. 25 and 26, considerable apprehension was felt as to the safety of the old piers during the sinking of the adjoining new piers. To obviate any trouble, single rows of United States interlocking steel sheet piling were driven in elliptical form around these piers to elevations believed to be 20 ft. below the bottom of the piling in pier No. 25 and 20 ft. below the crib in pier No. 26. The actual settlement experienced was slight, about 2 ins. at the south end of No. 25 and ½-in. at the south end of No. 26.

The caissons were of the usual type of wooden deck caissons. Fig. 7 shows the details of the masonry and caisson for pier No. 26. Fig. 8 shows the same for the center pier, No. 27. Two blow pipes, one each near the upstream and downstream ends of the caisson, were used for forcing out all fine material. One Moran lock, located near the center of the caisson, handled all coarse material excavated; this was used also for the ingress and egress of the men and the placing of concrete for sealing.

The abutments (Nos. 24 and 29) were built of cut stone masonry from the Ablemans (Wis.) red-rock quarry. All the other piers in this section above the crib line were of dimension stone from the Ablemans white-rock quarry. The quantities were as follows: Timber in cribs and caissons, 520,000 ft. B. M.; concrete, 5,850 cu. yds.; dimension stone masonry, 3,328 cu. yds. Material was all brought to the site over the temporary wooden pile trestle and handled with two stiff-leg derricks (supported on piling) at each pier.

SUPERSTRUCTURE.—The four spans in this section are from east to west as follows: One through riveted lattice span, 146 ft. 5½ ins.; one through riveted Pratt truss span, 182 ft. 5½ ins.; one through pin-connected swing span, 460 ft. c. to c. of end floorbeams, and one deck plate-girder span of 52 ft. 7½ ins.

By Dec. 12, 1908, the center of the draw span was all in and riveted, and the west arm erected complete. Piles were all driven in the falsework of the fixed spans and for a few bents of the east arm of the draw. River navigation closed for the season Nov. 15, 1908. Falsework in the east arm of the draw was started soon after, but was partly carried out on Dec. 3.

FIG. 6. END VIEW OF THE EAST CHANNEL SPANS (LOOKING WEST); SHOWING THE DECK CONSTRUCTION.

(On the right is the old single-track bridge. On the left is the high-level highway bridge.)

The draw span is being erected by means of a three-bent double-rail traveler, but it is the intention to put up the fixed spans with derrick cars. The estimated weight of the draw span is 2,225 tons; and of the entire west channel superstructure, 3,107 tons.

The draw will be operated by two 45-HP. electric motors operating the turning mechanism, and two 20-HP. motors (one at each end of the draw) operating the end lifts. Power will be furnished from a power-house located on the west bank. The prime movers will be two 50-HP. two-cylinder vertical Otto gasoline engines, working either directly through electric generators, or through the latter and a Westinghouse storage battery.

It is the intention to have the spans entirely finished, traffic turned over, and the old west channel spans removed before the opening of navigation in the spring of 1909. Traffic was turned over the new east channel and slough spans on Aug. 4, 1908, the turnout from the east channel spans of the new bridge to the west channel spans of the old bridge being on Little Rock Island.

Notes on the Design of the Steel Superstructure.

SPECIFICATIONS.—The moving load assumed throughout for each track is Cooper's E-50, consisting of two 177.5-ton consolidation engines coupled, followed by a uniform load of 5,000 lbs. per lin. ft. The assumed weight of the deck is 550 lbs. per ft. of track. Impact is added to the moving load stresses in accordance with the Pratt formulas: (A) for stresses resulting from live load on one track; (B) for stresses resulting from live load on two tracks. In these formulas L = live-load stress; D = dead-load stress; I = impact.

$$\text{(A) } I = L\frac{L}{L+D} \qquad \text{(B) } I = \tfrac{3}{4}L\frac{L}{L+D}$$

The unit stresses used are substantially those proposed by Mr. C. C. Schneider, and as adopted by the American Bridge Co.

The trusses are spaced 32 ft. c. to c., which is wider than ordinary. This is in order to allow derailed cars to reach the guard timbers without striking the trusses. The minimum lateral clearance for trains is 8 ft. from the center lines of the tracks. The minimum vertical clearance is 22 ft. 6 ins. from the base of rail, with the usual allowance for brackets at the corners of the clearance rectangle. The tracks are 13 ft. c. to c., and stringers and girders are spaced 3 ft. 3 ins. from the center lines of their respective tracks.

The requirements as to quality of material and workmanship vary but little from common practice. The bronze used in the turning mechanism and end lifts of the swing span is required to be made of new metals, and to show the following analysis: copper, 86%; tin, 13%; zinc, 1%.

Reaming is covered by the following clause in the specifications:

> In structural steel, wherever used in tension members, in top and bottom flanges, end connections and splices of floor beams and stringers of girders and beams, built or rolled, and in the web members of all riveted trusses, all punched holes shall be reamed with a twist drill unless otherwise marked. In reamed work, the diameter of the punched hole on the die side shall be at least 3/16-in. less than the diameter of the finished hole after reaming.

DECK OR FLOOR CONSTRUCTION.—The deck construction is of the type which is standard for important steel structures on the Chicago & Northwestern Ry. It is shown in Fig. 6. The ties are of long-leaf pine, 8 × 8 ins., surfaced to a uniform thickness of 7¾ ins. They are 12 ft. long. An outer guard timber 10 × 12 ins., laid on edge and dapped 1 in. over the ties, is placed at each end of the ties. This is fastened to each tie with ⅞-in. bolts. Outside of each rail and at a distance of 4 ins. from the inside flange, is a plank 4 × 10 ins., laid flat and spiked to each tie. Inside the rail is a similar plank, with the nearest edge 9½ ins. from the inner flange of the rail.

Backed up to the latter plank (and between it and the rail) is an angle 6 × 4 × ½ ins., with the 6-in. leg bearing on the ties. These angles are attached to the inner planks with ½-in. screws 4 ins. long; they are fastened to every fourth tie with a track spike having the head lapping the edge of the angle. This deck system is continuous from backwall to backwall, except for ¼-in. expansion joints at the ends of each span. At each end of the bridge (and for the track approaching the bridge at that end), 60-lb. rails continuous with the angle guard rails are spiked to the embankment ties. These rails meet at a frog point 150 ft. from the backwall.

The theory of this plan of deck is that in cases of derailment the flanges of the derailed wheels on the inside of the track will be carried by the guard angle, and the treads of the derailed wheels outside the track rail will be carried by the plank, and so prevent cutting of the ties. This deck is the design of Mr. E. C. Carter, Chief Engineer of the Chicago & Northwestern Ry. In two cases in which it has been called into service it has performed its work perfectly. It has now been in use on this railway for 15 years.

Fig. 6 gives a good idea of the appearance of the deck. Particular attention is called to this deck construction on account of the statement

...by the writer of an article on "Some Historic British Bridges" in Engineering News, ..., 1908. At the close of this article is the following:

> ...rd with it [the bridge-guard system] our American ... of sending a train at 60 miles an hour across ... chasms with nothing but the track rails to guard ... destruction is at least a contrast.

...is correct with two exceptions: (1) It is ...stomary on American railways to send ... across high viaducts or trestles at 60 miles per hour; and this probably never happened except as a result of an accident, the speeds being usually limited to 20 miles per hour or less; (2) it is not customary to depend entirely on the track rail for protection, most railways providing inner and outer guards of more or less efficiency.

DETAILS OF THE STEEL SUPERSTRUCTURE.—In the girder spans across the slough, the cylinders are in pairs, those in each pair being 19 ft. 6 ins. c. to c. Cross girders 66 ins. deep bear on cast bed plates located on the caps of the cylinder piers. Fixed and expansion spans alternate. The fixed spans are riveted at both ends to the cross girders. The expansion spans are riveted at one end to the cross girder and at the other end bear on a casting carried by a suspension bracket, as shown in Fig. 9.

Fig. 9 shows also the arrangement of the section in the flange of the stringers, the idea being to provide a perfectly flat surface unobstructed by rivets or cover plates for the bearing of the track ties. As the ties are not dapped over the flanges of the girders this arrangement allows any defective tie to be removed without disturbing the track rail. This design is due to Mr. W. H. Finley, Assistant Chief Engineer, and was used first by him when Engineer of Bridges of this railway about 15 years ago. It has since been used in all deck girders requiring greater sections than two angles can furnish, and it is rapidly growing in general favor.

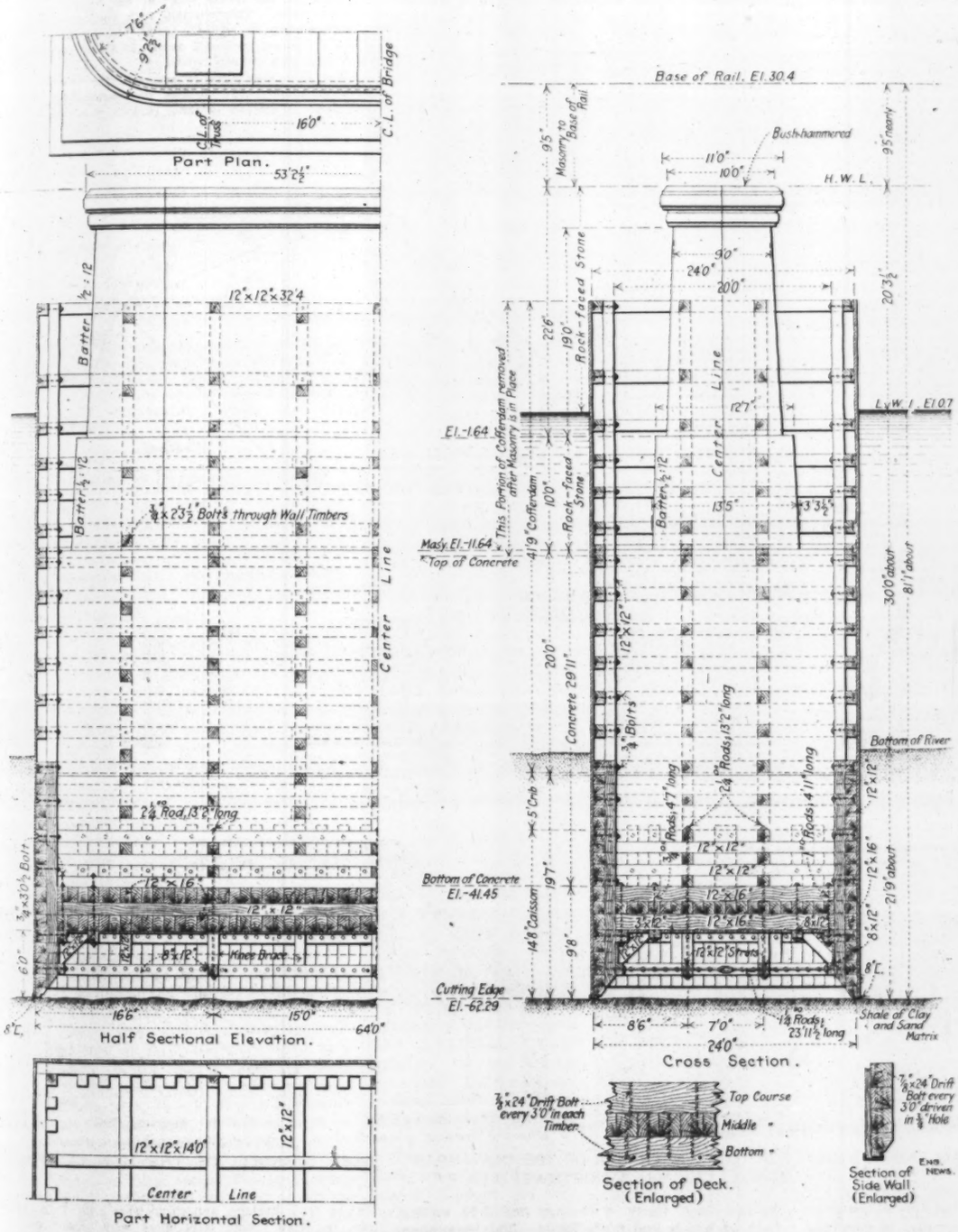


FIG. 7. CAISSON, COFFERDAM AND MASONRY FOR PIER NO. 26 (WEST CHANNEL) OF THE NEW CLINTON BRIDGE.

Of the east channel spans, span No. 14-15 (generally known as the "raft span"), 202 ft. 3¼ ins. long c. to c. of end pins, is the longest riveted fixed span on the Chicago & Northwestern Ry. The weight exclusive of deck is 565 tons. This span is shown in Fig. 5. It is 32 ft. wide c. to c. of trusses, 32 ft. deep c. to c. of chords at the hip suspender, and 42 ft. deep c. to c. of chords at the center. All connections are riveted, except the end connections with the shoes. Expansion joints are provided for the track stringers at one of the panel points adjacent to the center of the span. There are seven panels of 28 ft. 10¾ ins. each.

The expansion joints are similar in construction to that shown in Fig. 9. Expansion joints in the stringers are provided to reduce lateral bending in the flanges of the floor beams, and also to reduce longitudinal stress in the stringers and their riveted connections due to the elongation of the span under moving load. It can be shown theoretically and has been proved by Prof. Turneaure with extensometer experiments* that these stresses at times reach alarming proportions in spans of moderate length, when not provided against.

Fig. 10 shows the end floor beam and connection of the expansion shoe and rollers. Attention is called to the teeth provided at the ends of the rollers to prevent the latter from creeping. This device is believed to have originated in the engineering department of the Chicago & Northwestern Ry. It was first used eight years ago and has given uniform satisfaction. Since that time many other companies have adapted it.

Span 24-25 in the west channel, 182 ft. 5¼ ins. c. to c. of end pins, is similar in design to the 202-ft. span above noted.

The remaining spans in the east channel (with the exception of one 74-ft. deck plate girder span) are of the riveted lattice type. This type originated on the New York Central Ry. in 1850, as the work of Mr. Howard Carroll. For a great number of years it has been the accepted type of iron or steel truss on the Chicago & Northwestern Ry. for spans of 150 ft. and under. The bridges have given very satisfactory service, although in the older designs the floor beams were badly constructed.

This type is somewhat heavier than riveted Pratt spans proportioned for the same specifications where there is ample distance between the base of rail and the required under clearance for through spans. It does not appear to pos-

*Journal of the Western Society of Engineers, December, 1907.

sess any advantages over the latter system under such conditions. But where the clearance is limited, necessitating short panels and shallow stringers and floor beams, the riveted lattice spans are both economical and satisfactory. This is a fact which most designers have overlooked. The end connections with the shoes of these spans are pin bearings and the design of the roller bearings is similar to that shown in Fig. 10.

Fig. 4 shows the riveted lattice spans over the east channel. Span 24-25, in the west channel, is identical in design and construction with the east channel spans of the same length. The last span of the west channel is a plate-girder span of 52 ft. 10 ins., and is similar in construction to the plate girders of the slough spans, described above.

girders of the drum are arranged in the form of a square, with additional girders in the inner corners of the square so as to form an octagon. A circular tread is bolted to these outer girders. To the longitudinal outer girders of the drum are riveted a pair of cross girders bearing on a center which turns upon a lenticular bronze disk. Upon the completion of the span, half of the entire dead weight will be transferred to this center by means of hydraulic jacks, the weight transferred being measured by gages on the jacks. The remaining load will be carried by a live ring of wheels.

Test Borings for Foundations.

For the test borings at this bridge, a Sullivan diamond drill with 2-in. core bits was used. This

more serviceable. The tripod consisted of thr[ee] of Douglas fir 5 × 8 ins. and 32 ft. long. [a] wrought-iron pipe, near the center of the scow, a[nd] with a pipe flange to the bottom of the scow, [a] well for passing the 4½-in. standpipe and t[he] casing.

The materials encountered were in order as [fol]Recent alluvial sands; glacial drift of gravel, s[and] boulders; a shale consisting of sand with a clay [mix] and finally limestone bed rock. The upper stratum [of] rock was identified by fossils and general appear[ance] belonging to the Gower stage of the Niagara s[eries] silurian rocks. This overlaid rock conformably [to] Delaware stage of the same series. In the middl[e] river the Gower rock and nearly 50 ft. of the D[el]rock had been entirely eroded.

Great care was taken to ascertain the possibl[e] ence of subterranean pockets or overhanging [cl]the rock. Only two of these pockets were found

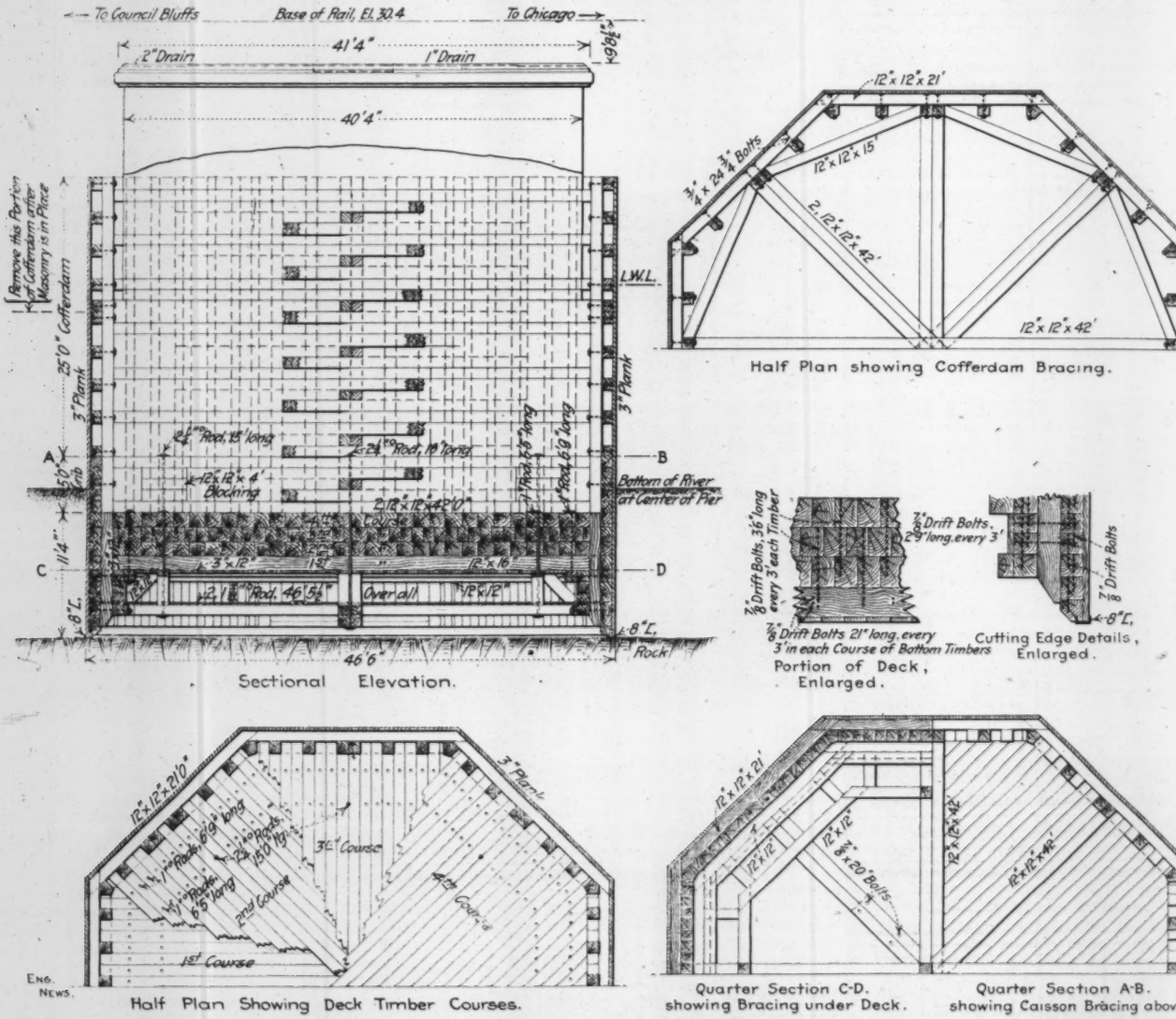


FIG. 8. CAISSON, COFFERDAM AND MASONRY FOR THE CENTER PIER OF THE DRAW SPAN (WEST CHANNEL) OF THE NEW CLINTON BRIDGE; CHICAGO & NORTHWESTERN RY.

DRAW SPAN.—The design of the swing span (460 ft. c. to c. of end floor beams) is governed by the limited clearance between the elevation of the high water line and that of the base of rail. This clearance is 9.4 ft., and it limited by three conditions: (1) a grade crossing with the Chicago, Milwaukee & St. Paul Ry., about 400 ft. west of the bridge; (2) connections with the Chicago, Burlington & Quincy Ry., in Clinton, adjacent to the west end of the bridge, and (3) a grade crossing of 2d St. in Clinton.

To avoid the questionable expedients of double drums, or an entire center bearing, the weight of each truss is carried to the drum by four posts arranged in pairs, as shown in Fig. 3. The

worked in a 4½-in. standpipe and 3-in. casing, both of which had flush joints. This equipment had been used previously at the Missouri River bridge of the Chicago & Northwestern Ry. at Pierre, So. Dak. From the article by Mr. Bainbridge, and mentioned above, in his reference to this part of the work we take the following particulars.

The same apparatus, tools, piping, etc., were used as at Pierre, but the manner of working and the materials encountered were essentially different. These borings were started in April, 1908, and it became necessary to mount the drill on a scow. The scow was 15 ft. wide, 32 ft. long on the bottom and 37 ft. long on top. Experience in rough water showed that a scow 10 ft. longer on top with somewhat more rake to the ends would have been

in the same boring), and these were only 1 in. and [6] ins. in depth. Both were filled with sand consisting of about equal parts of quartz and dolomite sand. Some of the borings were carried down 30 to 40 ft. into the bed rock to determine the possible existence of these subterranean pockets.

All the boulders encountered were such as could easily be broken with the chopping bit and no dynamite was found necessary. To determine the consistency of the shale, cores were taken out with saw tooth bits working dry, showing perfectly the consistency of the material. The saw tooth bit or the chopping bit working with the pump gave no idea of what this material was, and without the expedient of the dry core an excellent foundation would have been overlooked and a foundation sought 30 ft. lower.

Borings in the limestone were made with a bo[rt]

bit when the water was still and with the chopping bit, taking occasional cores with the saw tooth bits. Fully 95% of the boring in the limestone was made with the bortz bit.

The work of mounting the drill was started April 2, 1908, and the first hole started April 7, 1908. The work was finished June 6, 1908, working one 10-hour shift per day.

The aggregate length of casing put down was 692 ft. The aggregate length of casing driven through hard material was 406.5 ft. The aggregate length of borings in shale was 86 ft. The aggregate length of borings in limestone was 226 ft. The cost was as follows: Labor, $x6.16; coal, $124.41; depreciation of bortz (estimated), $200; scow, $287.24; depreciation on tools, pipe, etc., $300; total, $1,267.81.

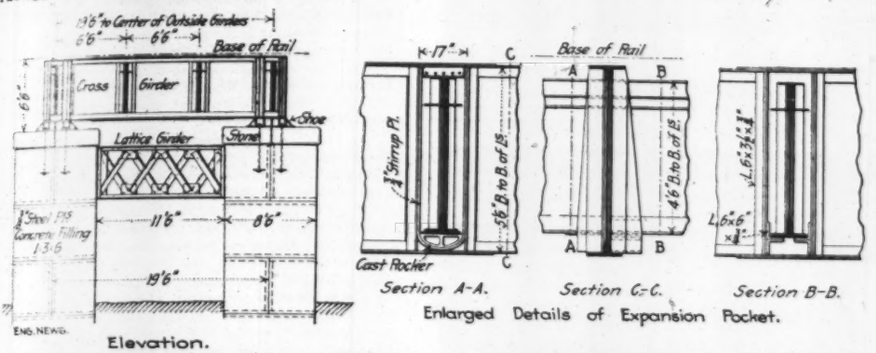


FIG. 9. PLATE-GIRDER SPANS FORMING THE SLOUGH CROSSING OF THE NEW CLINTON BRIDGE (WITH DETAILS OF THE EXPANSION BEARINGS).

Two Innovations in Launching Methods.

In launching the German cruiser "Blücher" at Kiel, last April, the engineers of the navy-yard introduced two new details, both of them fully successful. Naval Constructor Bock of the Kiel Navy-Yard describes these two novelties briefly in the "Zeitschrift des Vereines Deutscher Ingenieure" of Nov. 28, 1908.

SAND-BOXES.—Instead of wedging the ship up to transfer its weight from the blocking to the launching ways, the blocking was lowered away by means of sand-boxes. Sand bags have been used previously in a few instances, as in the launching of the U. S. battleship "Connecticut" (see "Recent Practice in Launching War Ships in the United States" Eng. News, Dec. 22, 1904, p. 563), but this is probably the first thoroughgoing application of the sand-jack principle to the support of ships in construction. It proved successful in every way; the whole transfer of weight was accomplished and the blocking cleared in 3 mins., and the ship settled uniformly, without any perceptible localized strain.

The launching weight of the ship was about 6,000 tons (6,160 tons moving weight). Some 130 sand-boxes were used to support the blocking, so that their average load just before launching was not far from 45 tons. It was important that they should lower away freely, without sticking, and to make sure of this they were tried in a testing machine before finally deciding their shape and details. The boxes used were rectangular cast-iron pots, 16 × 22 ins. in horizontal dimensions and 16 ins. high, in which fitted an oak plug with a clearance of about ⅜-in. on all sides. The boxes were filled a little over half full with burned molding sand. The plug, when set on the sand, projected 6 to 8 ins. above the pot. There were four sand holes through the walls of the pot, near the bottom. At first these were located in the corners, but in this condition the boxes were unable to lower a test load of 60 tons safely; the sand ran freely from the corners but bridged along the side walls, producing such high pressures that the pot showed signs of failure. After this test, the location of the sand holes was changed to the middle of the sides, and this arrangement proved satisfactory, the sand-boxes being able to lower a load of 80 tons without trouble.

For their stay under the blocking, the boxes were sealed against water and weather by tallow smeared into the top of the space between plug and box, and a wrapping of canvas over the joint, secured around the box and around the plug by lashings. This finish was successful in keeping the moisture even in the worst cases. The sand holes were threaded and closed by greased screws locked by a seal wire passing through a hole in the head of each screw.

When the ship was ready for lowering upon the ways, the wrappings and seal wires were removed, the screws turned back to the last thread, and then, on a signal, all screws taken out simultaneously. The sand flowed freely, except where it caught and piled up on the bed timbers so as to rise to the level of the holes, which interfered with the free flow; workmen stationed to watch the action of the sand-boxes had to keep these piles cleared away in order to avoid all chance of sticking.

The designers were so well satisfied with the performance of the sand-boxes that they expect them to become a regular feature of ship-building.

HINGED FORE-POPPET BEARING. — In place of the ordinary solid fore-poppets, the designers used two-part bearings fitted with hinge pins, each of the two bearings being exactly similar to the pin end-shoe of a bridge. When the rear of a ship enters the water and begins to lift off, it pivots on the fore-poppets. By this action the load on the fore-poppets is increased and the pressure is concentrated at their forward edge. At the Union Iron Works shipyard, San Francisco, the device of using crushing strips between cradle and sliding ways has been used successfully to reduce the concentration of pressure (see the article already cited). In the case of the "Blücher" recourse was had to a hinge bearing for the same purpose.

The bearing (one on each side of the ship) consisted of upper and lower shoes of built steel construction with cast-steel boxes, embracing an 8-in. pin. 40 ins. long. The lower shoe rested on an oak slipper 48 ins. wide by 20 ft. long (to carry 650 tons at point of pivoting). The upper shoe bore against a set of steel brackets riveted to the side of the ship and was tied longitudinally to the skin plating by horizontal gusset connections. The ends of the shoes embraced the pin, in order to carry the lower shoe when the ship floated. The slipper under the fore-poppet was connected to the main sliding ways under the cradle by steel plates set vertically in the slippers and bolted through each, to make a slightly flexible connection.

This novel form of support worked to the full satisfaction of the engineers. No trace of burning or smoking appeared at the ways.

The launch of the "Blücher" took place on April 11, 1908. The ways, laid on a slope of 1:14, were lubricated with about 1 lb. lubricant per square foot. They carried an average load of 2.34 tons per sq. ft., and a maximum load on fore-poppets (at pivoting) of 9 tons per sq. ft. The least friction coefficient calculated from the observations at launching was 0.0249.

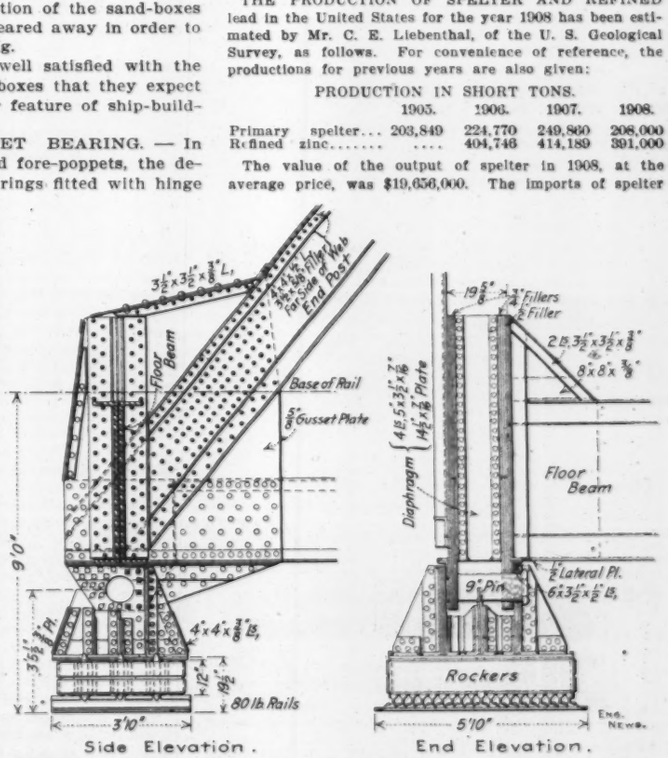


FIG. 10. DETAILS OF THE EXPANSION BEARING OF 202-FT. TRUSS SPAN OF THE NEW CLINTON BRIDGE; CHICAGO & NORTHWESTERN RY.

A SUBWAY SYSTEM FOR CHICAGO has been discussed by W. John Ericson, City Engineer, in a report which will form a part of the general report of the council committee on transportation. The suggested design would have four tracks, two for street railway cars and two for elevated trains. The platforms would be at the basement level of buildings. The subway would be owned by the city, and a rental charged for its use.

THE PRODUCTION OF COPPER in the United States during the year 1908 is given tentatively in a bulletin recently issued by the U. S. Geological Survey. The production of blister and Lake copper from ores mined in this country will exceed by about 6%, or 50,000,000 lbs., that of 1907, which was 868,996,491 lbs. Of the three principal copper producing states, Arizona and Montana show large gains while Michigan's production is about the same as in 1907. These preliminary estimates are based on the latest exact figures of the various companies, for eleven months in most cases, with estimates of their production for the remainder of the year.

THE PRODUCTION OF SPELTER AND REFINED lead in the United States for the year 1908 has been estimated by Mr. C. E. Liebenthal, of the U. S. Geological Survey, as follows. For convenience of reference, the productions for previous years are also given:

PRODUCTION IN SHORT TONS.

	1905.	1906.	1907.	1908.
Primary spelter...	203,849	224,770	249,860	208,000
Refined zinc.....	....	404,746	414,189	391,000

The value of the output of spelter in 1908, at the average price, was $19,656,000. The imports of spelter in 1908 amounted to 890 tons, showing a decrease of 50% from the imports of 1907. Nearly five times as much spelter was exported in 1908 as in 1907, the figures for the two years being 2,500 tons and 563 tons, respectively. The estimated value of the refined lead produced in 1908, at the average price, is $32,844,000. The imports of refined lead decreased from 9,277 tons in 1907 to about 3,000 tons in 1908, and the exports of lead from foreign mines smelted or refined in the United States increased from 51,424 tons in 1907 to 75,000 tons in 1908. Kansas leads in the production of spelter and Missouri retains first place among lead producing states.

A New Departure in Flexible Stay-Bolts.*

By H. V. WILLE,† M. Am. Soc. M. E.

There is practically no literature on the subject of stay-bolts, and this is particularly true of flexible stay-bolts. The increasing size and pressure of boilers make this subject of vital importance to railroads and to those responsible for the management of that type of boiler in which the firebox is stayed by a large number of bolts.

The boiler of the consolidation locomotive, now the prevailing type in freight service, contains about 1,000 bolts less than 8 ins. long and about 300 of greater length. The large types of Mallet compound locomotives now meeting with much favor have a much larger number, there being 1,250 short and 300 long bolts in locomotives of this class recently constructed.

In recent years some form of flexible stay-bolt, that is, one having a movable joint, has been very extensively used in the breaking zone of locomotive boilers, but their high cost and the difficulty of applying them, their rigidity due to accumulation of rust and scale and the fact that their use throws an additional service on the adjacent bolts because of lost motion have militated against their more general use.

It is well known that stay-bolts fail, not because of the tensional loads upon them, but from flexural stresses induced by the vibration resulting from the greater expansion of the firebox sheets than of the outside sheets, but notwithstanding the general acceptance of this theory, engineers have designed stay-bolts solely with respect to the tensional loads. It is quite general practice, it is true, to recess the bolts below the base of the thread, and this has effected a slight reduction in the fiber stress, but practically no effort has been made to design a bolt to meet the flexural stresses or even to calculate their magnitude. This is surprising in view of the simplicity of the calculations to which the ordinary formulae for flexure apply.

Let

F = fiber stress.
E = modulus of elasticity.
I = moment of inertia.
D = diameter.
N = deflection.
L = length.
W = load.

We then have

$$W = \frac{2\,F\,I}{D\,L};\quad N = \frac{W\,L^3}{3\,E\,I}.$$

substituting

$$N = \frac{2\,F\,L^2}{3\,E\,D};\quad F = \frac{3\,E\,D\,N}{2\,L^2}\ddagger$$

This formula shows that the stress increases in direct proportion to the diameter and decreases as the square of the distance between the sheets.

The application of the formula to service conditions gives the following stresses:

Conditions: Bolt spacing, 4 ins. c. to c.
Assumed expansion, 4/100-in.
Length of bolt, 6 ins.

Type.	Diameter of Bolt.	Flexural Stress
Iron	1⅛ in.	51,500
Iron	1 in.	45,000
Iron	⅞ in.	39,400
Spring steel	1 in. ends, 7/16 in. stem	19,700

Iron is universally employed in the manufacture of these bolts and it is not good practice to exceed a fiber stress of 12,000 lbs. per sq. in. It is apparent that stay-bolts in the zone which meets the expansion of the sheets

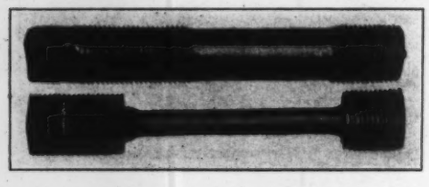


Fig. 4. Spring Steel and Regular Iron Stay-Bolts of Same Tensile Strength.

are stressed above the elastic limit and must necessarily fail from fatigue. Fractures always originate at the outside sheet at the point where the bending moment due to the movement of the furnace sheets is greatest.

*Published in the "Journal" of the American Society of Mechanical Engineers, January, 1909.
†Assistant to the Superintendent, Baldwin Locomotive Works, Philadelphia, Pa.
‡"Testing of Stay-bolt Iron," H. V. Wille, Am. Soc. T. M., vol. 4, 1904.

The fractures are in detail, usually starting from the base of a thread and gradually extending inward. Manufacturers of stay-bolt material have endeavored to minimize failures and to meet the unusual conditions of an iron stressed beyond its elastic limit by the supply of specially piled iron arranged with a view to breaking up the extension of the initial fracture. For this reason iron piled with a central section of small bars and an envelope of flat plates has met with much success for this class of service. In a further effort to secure an

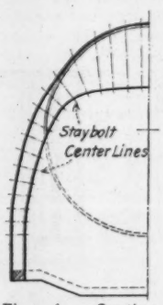


Fig. 1. Section Through Locomotive Firebox Showing Location of Stay-Bolts.

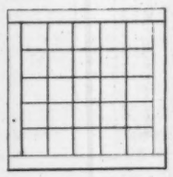


Fig. 2. Faggot Piling for Iron Stay-Bolts.

iron specially adapted to this class of work various forms of shock, vibratory and fatigue tests have been imposed. No design has yet been produced, however, which permits the employment of material of elastic limit sufficiently high to resist the flexural stresses, although a large class of material particularly adapted to the purpose is available.

It is obvious that the remedy does not lie in the use of a slow-breaking material but in the employment of material of sufficiently high elastic limit to meet the conditions of service. It is also possible to reduce the

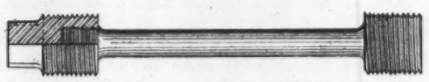


Fig. 3. Flexible Spring Steel Stay-Bolts With Soft Steel Ends.

diameter of the bolt greatly by the use of such a material, thus proportionately reducing the fiber stress in flexure.

Stay-bolt material, however, must possess sufficient ductility to enable the ends to be readily hammered over to make a steam-tight joint and to afford additional security against pulling through the sheets. To meet these conditions the bolt illustrated in Fig. 3 has been designed. The stem is of the same grade of steel as that used in the manufacture of springs. It is oil-tempered and will safely stand a fiber stress of 100,000 lbs. per sq. in. Its high elastic limit makes it possible to reduce the diameter to ⅝ or 7/16-in. or even less. The ends are of soft steel, and it is thus possible to apply and head up the bolt in the usual manner.

The employment of a stem of the diameter indicated reduces the fiber stress in flexure to less than one-half that in the ordinary type of bolt and it is of material capable of being stressed to a high degree. It has hitherto been impossible to employ in stay-bolts any of the steels containing chromium, nickel, vanadium or other metaloid possessing properties especially adapted to this class of work, but these steels can readily be used in the stem of the bolt described.

The stem of the bolt can be flexibly secured to the end in one of the customary ways, but the flexibility of the bolt does not depend upon a flexible connection. A type of bolt with a relatively inflexible connection, usually one in which the stem screwed into the ends with a running fit, met with the most favorable consideration. Such a bolt is flexible as a spring is flexible, in that it can be deflected to meet the requirements of service without exceeding the elastic limit. In fact the stem may be of a number of pieces, either of plates or small rods, thus increasing its flexibility.

The actual breaking strength of the bolt sizes ordinarily employed is shown in the accompanying table. These bolts were recessed to the base of the thread and tested in the same form as that in which they are employed in service. For comparison, the approximate weights of bolts of the usual length [illegible] also given. These weights are for bolts over the e[illegible] length, including the squared ends for screwing th[illegible] bolts into the sheets.

The vibrating test was made by clam[illegible] one end of the bolt in a machine and revolving [illegible] other end through a radius of 3/32-in., the specim[illegible] being 6 ins. long from the end of the right head to th[illegible] center of the rotating head. A tensional load of 4,00[illegible] lbs. was also applied to the bolts. The best grades of [illegible] bolts break on being subjected to from 5,000 to [illegible] rotations, whereas the spring steel bolts were [illegible] ted 500,000 times without failure, and on some of [illegible] in the test was continued without failure to 1,000[illegible] vibrations. These tests demonstrated that the bolt [illegible] not stressed beyond the elastic limit under these se[illegible] conditions and that the probability of its failure [illegible] less severe conditions is very remote.

The extent of the expansion which can [illegible] ke place in the firebox of a boiler can readily be calc[illegible]ed.

Distance betwen stay-bolts, 4 ins.
Temperature of inside sheet, 400° F.
Temperature of outside sheet, 100° F.
Coefficient of expansion, 0.0000066.

Then the expansion between the two bo[illegible] will equal $0.0000066 \times (400 - 100) \times 4 = 0.0079$, and [illegible]ch bolt will deflect 0.00395 in. It has been shown that this amount of deflection will stress the usual type of bolt beyond the elastic limit. In practice, however, one bolt may hold rigidly, throwing the entire deflection on the adjacent bolt, or neither bolt may deflect and the sheet will then buckle. Under this condition the neutral axis will assume the form ABC (Fig. 5) and the length AB will equal 2.00395 in. and the sheet will buckle to an extent $BD = \sqrt{2.00395^2 - 2^2} = 0.125$ in. It is obvious that the repetition of a force sufficient to buckle a sheet ⅛-in. must ultimately lead to a crack in the furnace sheets. If, however, the bolt deflects, allowing the sheet to normally expand, the latter will be relieved of these extraneous loads.

A bolt of sufficient flexibility to deflect under the forces following expansion, and of material which will not be stressed beyond the elastic limit in resisting these forces, will greatly assist in reducing the cost of boiler maintenance by eliminating broken stay-bolts and reducing the stresses in the furnace plates. If in addition the bolt has a smaller diameter the life of the furnace plates should be further increased, as such a bolt will interpose less obstruction to the circulation of the water in the water legs.

ACTUAL BREAKING STRENGTH OF STAY-BOLTS.

Type.	Nominal Diameter.	Actual Breaking Strength in lbs.	Weight.	Vibrations.
Iron	1-in.	32,500	20 oz.	6,000
Iron	⅞-in.	24,500	15 oz.	5,200
Spring steel stem	1-in. ends 7/16 in. stem	32,000	10 oz.	500,000

GRADE CROSSING REMOVAL IN MASSACHUSETTS since the passage of a state law providing for the work in 1890, has cost $30,682,177. Of this the railway companies have contributed $18,689,504, the state, $7,937,976 and cities and towns, $4,016,508. During the year ending June 30, 1908, there were 27 grade crossings abolished. The total number of grade crossings still remaining in the state is about 1,830. When the work of grade crossing removal began, in 1890, the total number was 2,235. During the last year 27 persons were killed and 30 injured at grade crossings. Over half these casualties occurred at crossings which were protected by gates or flagmen.

A NEW ROTARY ENGINE, invented by Mr. J. Emery Harriman, Jr., Exchange Building, Boston, Mass., has been recently tested at the Massachusetts Institute of

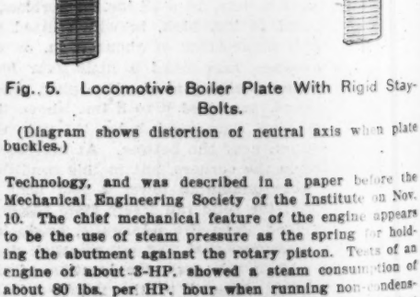


Fig. 5. Locomotive Boiler Plate With Rigid Stay-Bolts.

(Diagram shows distortion of neutral axis when plate buckles.)

Technology, and was described in a paper before the Mechanical Engineering Society of the Institute on Nov. 10. The chief mechanical feature of the engine appears to be the use of steam pressure as the spring for holding the abutment against the rotary piston. Tests of an engine of about 3-HP. showed a steam consumption of about 80 lbs. per HP. hour when running non-condensing and about 58 lbs. when running condensing. A test on Nov. 16 with superheated steam and the condenser connected showed steam consumption as low as 41 lbs. per HP. It is claimed that with engines of larger size very much higher economies would be easily obtained.

ENGINEERING NEWS

A Journal of Civil, Mechanical, Mining and Electrical Engineering

Published every Thursday by

THE ENGINEERING NEWS PUBLISHING CO.

220 BROADWAY, NEW YORK

BRANCH OFFICES

CHICAGO: 1636 Monadnock Block
WASHINGTON, D. C.: Home Life Building
ATLANTA: Candler Building
RUDOLPH MOSSE, BERLIN AND HAMBURG, GERMANY
Z. P. MARUYA & CO., Ltd., TOKYO, JAPAN

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There is a man in the city of Brooklyn who has saved more millions of hours of draftsmen's time, it is probable, than any other man in the United States.

Most engineers of mature age can easily recall the days when a necessary part of every draftsman's kit was a stick of India ink, and a necessary part of the day's work of every draftsman was grinding the ink in a saucer until it was in a condition for use. This grinding was always a rather slow process, and draftsmen who were inclined to loaf never expedited their work of ink-grinding.

Something like a quarter of a century ago, Mr. Charles M. Higgins, of Brooklyn, devised a scheme for putting India ink on the market in liquid form, which made unnecessary the old-time process of ink-grinding and enabled a draftsman to cut out that part of the day which he had formerly devoted to this restful task. It was from one point of view a very trifling invention, but it has, as we have said above, saved a greater amount of hours of drafting-room labor than almost any other invention for draftsman's use that we can now recall.

It will be seen from the above that Mr. Higgins long ago made a hobby of saving. He recently had an opportunity to practice this hobby in a way that has attracted wide attention.

During the financial crisis of October, 1907, the Brooklyn Bank—the oldest banking institution in the City of Brooklyn—was obliged to close its doors. Now it is a time-honored custom when a concern is placed in a receiver's hands, for the court to allow huge fees to all the lawyers concerned. Lawyers of good reputation seek appointments as attorneys in receivership cases and charge fees for their services amounting to a small fortune. In fact, the division of spoils among receivers and their attorneys when a large corporation is in financial trouble has come to be looked upon as a sort of legitimate perquisite of the legal profession.

It might seem to an outsider, unaccustomed to these things, that the time when an enterprise is in distress and its creditors need all the assets that can be saved, is the very time when it ought not to be burdened with heavy legal expenses. The courts, however, take a contrary view, and under their auspices it is the custom for a swarm of attorneys to settle down upon the carcass of a defunct enterprise and strip the flesh from the bones, like a lot of vultures. The creditors usually consider themselves lucky if the bones are left.

Nor is the allowance of exorbitant fees the only method by which a concern's assets are looted during a receivership. It is easy enough under one plea or another to sacrifice valuable property through forced sales in times of financial stress, and some one always reaps a profit from every such sacrifice.

Under the threat of such conditions an association was formed among the largest depositors of the Brooklyn Bank, to protect the interests of all the depositors, and Mr. Higgins, whose firm was among the largest depositors, was made Chairman of an Executive Committee of Fifteen which undertook the fight to conserve the bank's assets. The court had appointed as temporary receiver for the bank a man who was not a resident of Brooklyn, and one in whose selection the depositors were not consulted. Under the urgent demand of the Depositors' Committee Mr. Higgins was appointed as co-receiver. With the co-operation and aid of the committee he conducted a successful fight for the protection of the bank's assets, and on June 23, 1908, the bank was reopened for business without restrictions as to withdrawals of deposits.

When Mr. Higgins accepted the co-receivership he pledged himself to the depositors to accept only such fees as would be satisfactory to all interests concerned. At the conclusion of the receivership the court awarded to Receiver Bruyn Hasbrouck the sum of $23,000 and to Receiver Chas. M. Higgins the sum of $19,000. Mr. Higgins figured out that under the New York State law a receiver's fees ought not to exceed 2½% on the moneys handled. As this would make his legal fee about $15,000, he returned $4,000 of the amount which he had received to the Brooklyn Bank.

Of the amount remaining he paid $5,300 to the Depositors' Committee toward the expenses it had incurred in its campaign for the protection of the bank's assets. About $5,700 was retained to meet legal services and other necessary expenses which he had incurred in conducting the receivership. Of the remaining $4,000, Mr. Higgins has contributed $1,000 to the Brooklyn Institute of Arts and Sciences as a memorial of the remarkable fight against extravagance in receiverships which his committee conducted, and the remaining $3,000, temporarily retained in case further expenses should arise from the work done in connection with the receivership, will probably be ultimately returned to the bank.

This remarkable and unprecedented conduct by a receiver has attracted general attention in the city of Brooklyn, and it has seemed to us deserving of a much wider publicity. In the State of New York the legalized graft carried on under the protection and direction of courts of justice in connection with bank liquidations became such a notorious scandal that the Legislature of 1908 enacted a law placing the affairs of suspended banks under the control of the State banking department.

Similar reforms, however, are needed in other states and in the economical conduct of business firms in financial difficulties as well as of banks.

We wish Mr. Higgins' idea of operating receiverships economically might be as successful as his achievements in economizing time in the drafting-room.

Such accidents as the collision at Dotsero, Colo., on Jan. 15, are periodical reminders of the fatal weaknesses of the train-order system of moving railway traffic. Their lesson is thoroughly well known and only finds reiterated confirmation in the regular sameness of the attendant circumstances, which move in the narrow range of three or four detail variations. The cumbrous complexity of the system is perfectly recognized by all who are familiar with railway operation, and the chances for breakdown bear direct ration thereto. The layman may be misled by noting that in every case some one person may be charged with direct blame for the accident: if the orders are wrong, it is the dispatcher's fault; if they are not properly transmitted to the train, an operator is responsible; if they are disobeyed or misinterpreted the blame falls on the train crew. But he should bear in mind that the real fault is in the system, if this is so complex or unwieldy as to invite instead of neutralize the inevitable human propensity to err.

Some years ago a railway officer, speaking before a technical society, gave a graphic description of the workings of the train-order system. He described the progress of a train over a busy single-track division, and told of the tripartite authority of printed timetable, dispatcher's meeting-point orders, and time, all three of which the train crew must dovetail together into a perfect fit. He explained that before the train reached its division terminal, the engineer had accumulated several dozen orders for changed meeting-points, of which each order contained the chance of a collision, needing only a miscalculation of a few minutes of time, or the forgetting of a single item in orders or timetable, to bring it about. The description carried its own moral, namely, that under the conditions it is simply out of the question to look for complete infallibility of the trainmen—they would need to be superhuman. In other words, we must expect collisions now and then. The facts do not belie this conclusion.

All this means simply that block working, of some kind, must be made universal just as rapidly as the necessary forces can be brought to bear. The work of the Block Signal and Train Control Board of the Interstate Commerce Commission, whose first report we printed last week, can do valuable service in furthering this end.

A novel proposal for stay-bolts of locomotive boilers is made in this issue by Mr. H. V. Wille, M. Am. Soc. M. E., of the Baldwin Locomotive Works. As is pretty well known, locomotive stay-bolts break, not from direct tension, but from bending due to the difference in expansion of the inner and outer sides of the fire-box. The present practice is to use very soft iron for these stay-bolts, which will stand frequent bendings without fracture. Experiments have also been in progress for fully a score of years with flexible stay-bolts having a ball and socket joint at one end, and some stay-bolts of this type have come into quite extensive use. Rust and scale, however, tend to make any such joint inoperative. Mr. Wille's proposal is to use a high carbon spring steel for stay-bolts, and increase the unit tensile stress. The stay-bolt thereby becomes of so small diameter that the bending it receives does not stress it beyond the elastic limit.

The proposal seems sound from every point of view, with the one exception of the effect of corrosion. If these bolts corrode at the same rate as ordinary iron bolts, at the end of a given time, the loss of say 1/32-in. from corrosion will represent a very much greater reduction in strength than would be the case with an ordinary iron bolt. Perhaps it would be feasible to use an alloy steel with a high percentage of nickel, such as has been used for boiler tubes in the navy. This material resists corrosion to a remarkable degree. While the cost per pound is high, the amount of material would be so cut down by the small size of the bolt that its use might still be commercially practicable.

Some objection may also be raised to the new bolts on the ground that the ends cannot be drilled so as to give automatic warning of breakage. If, however, the bolt can be made strong enough to be secure against breakage, this objection would not be important.

Many people of intelligence still hold the idea that the Administration at Washington was in some way to blame for the panic and business depression of 1907-8. Those who hold this opinion ought to consider the fact that the business de-

pression has been even more severe in Europe than in America.

It is commonly claimed that the railways of the United States have suffered as severely as any industry during 1908, but the statistics of the Interstate Commerce Commission, published in our last issue, show that the gross earnings of the railways in the year ending June 30, 1908, were actually nearly $100,000,000 in excess of the earnings for 1906, and nearly $350,000,000 in excess of the earnings for 1905. It never occurred to any one to call those panic years.

In contrast with the comparatively moderate falling off in railway business in 1908, it is interesting to notice the terrific loss of business in the shipbuilding industry of Great Britain last year. As most of our readers know, shipping occupies as important a position in Great Britain as railway transportation does in the United States. Our contemporary, "Engineering" of London, in its issue of Jan. 1, published full statistics of shipbuilding and marine engineering construction in 1908. The total output of British shipyards in 1908 was only 1,077,200 tons, while in 1907 the output was 1,847,200 tons. In 1906 the record of 1907 was exceeded, the output being over 2,000,000 tons.

An even better idea of the terrible collapse of the shipbuilding industry in Great Britain is gained from the statement that a lower figure of output than that of 1908 has not been recorded since the year 1893. It is also interesting to note that, whereas all observers agree that business in the United States is now on the up grade and a steady recovery during the coming months may be expected, no such pleasant outlook is seen abroad. The editor of "Engineering", in his review of the prospects of shipbuilding in Great Britain says: "Those who affect to see any soundly based permanent indications of improvement must be ranked as optimistic."

Two Important Supreme Court Decisions on Rate Regulation.

Two decisions of the U. S. Supreme Court made public on Jan. 4 place a milestone to mark progress toward intelligent government control of public service corporations. The cases in which the decisions were rendered were the so-called 80-cent gas case in New York City, and the case against the Knoxville Water Co., of Knoxville, Tenn.

In both these cases the official authorities had fixed the rates which the public service corporation might charge; in both these cases the corporation had sought the U. S. courts on the plea that the rates charged amounted to confiscating its property without due process of law, and were therefore contrary to the 14th Amendment to the United States Constitution; in both these cases the lower federal courts had decided favorably to the companies, on the whole; and in both these cases the highest judicial authority in the land—the federal Supreme Court—has now upheld the rate-making power.

In one sense, these decisions contain nothing new or in contradiction to what has previously been established by other decisions of our highest court. But the importance of these cases and the publicity they have received, together with the firm stand taken by the Supreme Court in support of the rate-making power, makes it certain that the right of the public to regulate monopolies, particularly those engaged in municipal service, is established on a firmer basis then ever before by these important decisions.

The 14th Amendment to the Federal Constitution, as some of our readers may recall, was adopted subsequent to the Civil War. It was without doubt one of the most important results growing out of that contest. While it was enacted partially to secure civil rights to the enfranchised colored people of the South, its effect in giving broad powers to the nation and, in fact, making the United States a real nation rather than a mere federation of independent commonwealths, surpasses that of any other clause or amendment of the Constitution. The part of the 14th Amendment with which the recent rate-fixing litigation is concerned reads as follows:

> No State shall make or enforce any law which shall abridge the privileges or immunities of citizens of the United States; nor shall any State deprive any person of life, liberty or property without due process of law.

It will be seen that the whole litigation over the rate-fixing power rests upon the statement that no state shall deprive any person of property without due process of law. The contention in the New York gas case, in the Knoxville water case, and in hundreds of other similar suits which have been before the federal courts in the last ten years, has been that when a state, by some official authority, fixed the rates to be charged by a public service corporation, it was depriving the owners of that corporation of their property. That the courts will interfere to prevent actual confiscation is of course established, and nothing in the recent decisions controverts this. But the confiscation must be well established, and the whole tenor of the recent decisions is to discourage the resort to the courts in any of these cases where there is any doubt as to whether the corporation is really being held down to less than a reasonable rate.

And here it should be pointed out that the whole question really turns on the interpretation of what a reasonable rate really is. Upon this point the recent decisions are explicit to a gratifying degree. It is declared that a reasonable rate is one which will pay the operating expenses, will keep the plant in good condition so far as current repairs are concerned, will offset depreciation of the property, and will in addition leave sufficient profit to pay a fair return upon the actual value of the plant used by the company in carrying on its business. As to what is a reasonable return on this investment, the Court very properly indicates that this will vary in different places and with different lines of business.

In a new country, where capital commands a high rate of interest, a larger return must of course be allowed. So, also, with a business which involves large elements of risk, a high rate must be allowed, in order to induce capital to make the investment.

The company is also entitled to have the present value of its property considered, in fixing the amount on which the return is to be based. For instance, a water company or a railway company may have acquired real estate for its business, which has greatly increased in value since its purchase; this increase in value it is of course entitled to earn an income upon. On the other hand, the Court does not look with favor upon the plea that the companies are entitled to have their franchises or good will appraised as part of their property on which an investment is to be earned. Concerning this the Court says, in the Consolidated Gas case:

> We are also of the opinion that it is not a case for the valuation of good will. The Master [who made the investigation for the lower court] combined the franchise value with that of good will, and estimated the total value at $20,000,000. The complainant has a monopoly, in fact, and the consumer must take gas from it or go without. He will resort to the "old stand" because he cannot get gas anywhere else. The Court below excluded that item, and we concur in that action.

It is well worthy of note, too, that the commonly held claim to the effect that the total capitalization of a company has something to do with the value on which it is entitled to earn an income, is wholly discredited by the Supreme Court. In its decision in the Knoxville water case, the Court naively says:

> Counsel for the company urge rather faintly that the capitalization of the company ought to have some influence in the case in determining the value of the property. It is sufficient answer to this contention, that the capitalization is shown to be considerably in excess of any valuation testified to by any witness, or which can be arrived at by any process of reasoning. * * * Bonds, and preferred and common stock, issued under such conditions, afford neither measure of nor guide to the value of the property.

Another point constantly brought forward by the enemies of government regulation is that the legislature alone has the right to fix rates, and that it cannot delegate the right to other bodies. In the Knoxville water case, however, the rates under litigation were fixed by an ordinance of the city of Knoxville, enacted on March 30, 1901. Concerning this the Court says:

> The function of rate-making is purely legislative in its character, and this is true whether [it] is exercised directly by the legislature itself or by some subordinate or administrative body to whom the power of fixing the rates in detail has been delegated. The completed act derives its authority from the legislature and must be regarded as an exercise of the legislative power.

It is extremely important that this principle has been authoritatively laid down by the Court; for all students of government concede that if rates for public service corporations are to be fixed by public authority, the work can be far better and more equitably done by an administrative bureau or commission than by the legislature itself. This very case of the 80-cent gas bill in New York is a case in point. The act was passed in deference to public agitation demanding that the high rates charged for gas in New York City should be reduced; but no one would pretend that the members of the legislature who voted for or against that act possessed sufficient technical knowledge to judge whether that rate was or was not a reasonable one.

The same principle is involved in the legislation establishing a maximum rate of passenger fare of two cents per mile. Such an act was passed in New York State, but was vetoed by Governor Hughes on the ground that such acts should properly originate with the Public Service Commission, which alone could command the necessary expert knowledge to determine the reasonableness of rates charged for railway passenger traffic.

In view of the explicit statement by the Supreme Court on this point, the arguments against giving to State Public Service Commissions authority to fix rates is effectively silenced. If intelligent and fair rate making is to be done at all, by public authority, it must be done by such bodies. It is absurd to suppose that legislatures are competent to perform such work, which is as a matter of fact executive and not legislative in its nature.

And there can easily be read in the Supreme Court decisions also, a warning to the extremists and the demagogues, who clamor for direct legislation on railway rates, such as the 2-ct. a mile passenger laws for example.

The Supreme Court says to the investor who has placed his money in an honestly managed and honestly capitalized public service corporation, that the power of the Federal Courts will be exercised to protect his property from actual confiscation by unjust and unfair legislation such as will reduce the return upon it to less than a reasonable figure. But any such investor must expect that his company will be subject to public regulation, and in the long run it will not be permitted to earn dividends on water in its capitalization. Further, the courts will not interfere with such public regulation unless a clear case of confiscation is made out; and resort to the courts in any doubtful case is distinctly discouraged.

It is fortunate, indeed, that the Supreme Court has laid down this so distinctly. We are at the end of the long debate over the question whether the public, through its lawfully constituted representatives, may protect itself against the extortions of natural monopolies. We are at the threshold of an era when the rates charged by all so-called public service corporations will be regulated by public authority. If the corporations affected pursue an obstructive course and continually appeal to the courts, such a vast volume of litigation will be started as will absolutely block the wheels of justice.

The Supreme Court foresees the possibility of such a condition and urges public service corporations to give a fair trial to rates fixed by public authority before resorting to the Courts. We trust its advice will be heeded by those men in charge of our public service corporations who are big enough and broad enough and patriotic enough to consider the needs of our common country.

Are the public service corporations willing to make a fair trial of public regulation? If they are, it is probable that public regulation can be made the American solution of the problem of monopoly. But if they prevent—as they doubtless can—the success of Government regulation, they will drive the people to the other alternative of Government ownership.

LETTERS TO THE EDITOR.

Glory vs. Dollars.

Sir: Please will please discontinue my subscription to the News. [illegible] course is taken not from any dissatisfaction with [illegible] magazine, which I consider an excellent technical [illegible]nal, and I would certainly continue it were I going [illegible]llow this line further.

But [illegible]e come to the conclusion, after wasting a few years [illegible] an experiment (in which I attained reasonable s[illegible]ss) that Engineering as a profession has a great [illegible] of glory in the eyes of the Engineer, but offers too litt[illegible]turn financially upon the investment of education [illegible]perience that it requires. While still young I have [illegible]rmined to start again, bequeathing my share of the [illegible] to other seekers for fame, content to applaud their [illegible] from obscure but comfortable quarters.

Wishing you every success and a large factor of safety,

Yours very truly,

"Assistant Engineer."

Alabama, Dec. 29, 1908.

A Hint to Contributors to Technical Literature.

Sir: In your issue of Dec. 3 you give some very interesting views of a large dam near Sydney, New South Wales.

I would like to say, however, that a cross-section would be quite as interesting. To me, personally, it would be about all I would care to see, if from it I could get the factors of safety. It is strange that so little is ever said about the coefficient of friction assumed on the factor of safety against sliding or overturning in dams.

I cannot understand how engineers can derive any pleasure in looking at pictures of a dam when they do not know its strength as compared with the pressure it will be called upon to sustain.

I have noticed in many cases in different engineering journals and your own very excellent one among the number, that, even when a dam cross-section is given, no mention is made of the factors of safety. I like to come across a description of a dam with factors of safety that are worth boasting of, but I am usually obliged to figure them out for myself, from what is often insufficient information, and it looks as though others cared very little about this matter.

I may be peculiar in this regard, but a pretty picture of a dam with fine curves, excellent paneling along the top, etc., seems to me to be as "sounding brass or tinkling cymbals" if one is not assured that "strength" is there.

I am, yours truly,

Jno. S. Fielding.

Toronto, Ont., Jan. 11, 1909.

A Simple, Easily Remembered Pipe-Discharge Formula.

Sir: Probably many hydraulic engineers have felt the necessity of a pipe-discharge formula so simple that it may be readily remembered and worked out in the field in the absence of tables, etc. I have for many years made use of the formulas given herewith, in which

Q = Discharge in million gallons daily;
S = Slope or loss of head per unit of length;
D = Diameter of pipe in feet.
d = Diameter of pipe in inches.

$$Q = 25\ D^3\ \sqrt{Ds},\ \text{or}$$

$$Q = .05\ d^3\ \sqrt{ds}.$$

These above formulas are modifications of the Chezy formula and in the first, $c = 98.6$, while in the second formula it equals 98.4. These values will be found to be conservative for cast iron up to 30 ins., being about 10% within average results. Above 30 ins. the formulas give correct values for riveted steel pipe, being also conservative for this purpose, but for these large sizes the values are of course too small for cast iron. They are, therefore, admirably adapted for use for long gravity mains or force mains or sewer outfalls, since 30 ins. in diameter is about the size above which it becomes more profitable to use steel than cast iron. These formulas are so simple that it is often easy to work out results mentally with an accuracy which is all sufficient for ordinary purposes.

Yours truly,

C. C. Vermeule.

203 Broadway, New York City, Jan. 11, 1909.

Durability of Creosoted Piles in the Caribbean Sea.

Sir: In reference to the article in your issue of Jan. 7 [illegible] the Galveston bridge, it may be of interest to note a [illegible]what similar instance of the effectiveness of creosoting as a preventative against the attacks of the teredo.

During the year 1892, the Cartagena Railroad Co. built a fairly large wharf at Cartagena, Colombia, S. A., the work being done by a contractor whose name, unfortunately, I do not now remember, but whose plant, I believe, was located at Mobile, Ala. The whole of the structure was of creosoted yellow pine.

I was reliably informed as late as 1904 that there was absolutely no signs of decay at that time, and that a short time previously, when, owing to some damage done by a steamer, some of the timber and piles had to be replaced, the old material was found to be in as good condition as new. The management of the railway was so pleased with the condition of the structure at this time, that they sent an official letter of thanks to the contractor in recognition of the good quality of the creosoting; which, by the way, I believe, was done without any inspection on the part of the Railroad Company.

Yours very truly,

"Resident Engineer."

New York, Jan. 11, 1909.

Successive Firing in Rock Tunnel Headings.

Sir: I note in your issue of Dec. 31, 1908, an article by Mr. Walton I. Aims on the methods employed in driving the headings of the Loetschberg tunnel. Mr. Aims describes with some detail and characterizes specifically as somewhat different from American practice a method of blasting which is, I believe, familiar to every engineer who has had charge of mining operations or of a tunnel work in the western states. Firing by time fuse, carefully cut to fire the center cut before the side rounds is in common use and much in favor in this country. We find that in this way we secure better results with the expenditure of less powder than could be secured by the simultaneous firing of all holes in the face, and I think the method enables us to control overbreakage a little better. There is, of course, an element of danger from missed holes and defective fuse, which is eliminated by electric firing.

A careful study of Mr. Aims' article has left me with the impression that the engineers on the Loetschberg tunnel have endeavored to minimize the time lost in withdrawing and replacing the drill, and in mucking. To this end they have devised a novel drill mounting, and have, I gather from Mr. Aims' description, adopted a working system involving lighter blasts than would find favor with many engineers in this country.

While the progress on the Loetschberg tunnel has been at a rate far better than the American record, I cannot find in Mr. Aims' article ground for his closing observation that a study of European methods would enable American engineers to equal European progress records in tunnel work.

Yours truly,

Albert G. Brown.

St. Joseph, Mo., Jan. 8, 1909.

A Proposed Crown Formula for Macadam Roads.

Sir: While it is true that the ordinary macadam road or street is being rapidly replaced by some form of bituminous macadam, there are still, no doubt, large sections of the country where the automobile is little used and in which the macadam or telford will, on account of its comparative cheapness, hold its own for many years to come.

Considering this last, and the long number of years since macadam first came into common use, it seems strange that there should be so little uniformity of practice in certain details of construction, as for instance the crown suitable for such a roadway. Some greater advance has been made on this line as regards the more permanent forms of street paving, and possibly the best practice of to-day is embodied in the formulas worked out by Mr. Andrew Rosewater, City Engineer of Omaha.

It has occurred to me that some formula of the same general form as the Rosewater formulas might be devised for macadam construction; perhaps the following:

$$c = \frac{w\,(100 + 8\,f)}{2{,}500},$$

in which c = the crown of the street in feet, w = the width of the street in feet, and f = the grade of the street in feet per hundred. This formula indicates a crown-height varying from 1/25th the width for a level street to about 1/14th for a street on a 10% grade.

The formula, in its present shape, is intended for use on a well-built city street, where repairs are attended to fairly promptly and a good quality of well-binding rock is obtainable. It can, of course, be modified to suit conditions not so favorable by inserting a constant factor "a," the value of which can be determined for the particular circumstances governing by the judgment of the engineer in charge of the work. In fact, the same formula can be made to apply with a like variation to some of the various forms of bituminous macadam.

I should be glad to have the opinion of the profession as to the desirability of a formula to serve the purpose this formula is designed to fulfill, and also as to the correctness of the values given to the constant factors.

Yours truly,

S. D. Newton, City Engineer.

Knoxville, Tenn., Jan. 6, 1909.

Machine vs. Hand Mixing for Concrete Curb and Gutter Work.

Sir: In a recent treatise on concrete it is stated that "concrete sidewalk and curb work are essentially hand mixing work." It may be of interest to record certain figures, which do not accord with the above statement. In the following comparison the figures on hand-mixing are taken from Gillette's "Cost Data" and apply to curb and gutter work done at Champaign, Ill. The figures on machine mixing are for combination curb and gutter work done under my immediate supervision.

The cost given for machine mixing is the average cost per lin. ft. of 8,465 lin. ft., and includes all items of labor, charge for plant, coal, etc., and superintendence.

	Hand-mixing.	Machine-mixing.
Average wage, per hour	19.7 cts.	30.7 cts.
Material handled per 100 lin. ft.	4.6 cu. yds.	10.1 cu. yds.
Cost per lin. ft., labor	9.33 cts.	21.1 cts.

Reducing wages per hour and material handled to the standard of 19.7 cts. per hr. and 4.6 cu. yds. per 100 lin. ft. we have a labor cost of 6.2 cts. per lin. ft. for the machine mixed, against 9.33 cts. for the hand mixed, showing a saving of 34%.

The average cost of 21.1 cts., as given above is high, as neither the laborers nor the finishers were familiar with the work and the duration of the work was very short. Toward the close the labor cost was 14.7 cts. per lin. ft., wages and material handled remaining the same; reducing as above we have 4.3 cts. per lin. ft. for the machine mixed, against 9.33 cts. for the hand mixed, a saving of 54%.

While the reduction in cost is not always in the same proportion as the reduction in material handled, in the above instance it would be very nearly so.

The following cost data on cement sidewalks using machine mixer are also interesting.

The walk was built on the ground, which was tamped after being excavated to subgrade, it consisted of a 3-in. base of 1:3:5 concrete and 1-in. finish coat composed of one part each of cement, sand, and pea-gravel, at drive crossings the base was made 5 ins. thick. A mixer with gasoline power was used.

The average wage per hour was 29 cts., finishers being paid 50 cts. and laborers 25 to 40 cts. per hr. The average gang, finishing subgrade, setting strips and laying walk, consisted of 43 laborers, 1 engineer and 3 finishers, the average 8 hrs. work was 5,163 sq. ft. of walk 6 ft. wide. The area covered at the following cost was 169,524 sq. ft. of 4-in. walk and 6,012 sq. ft. of 6-in. walk. The labor cost includes all items of labor, charge for plant, fuel and superintendence; finishing subgrade is included, but no excavation.

	Totals.	Cost per sq. ft.
Total labor, etc.	$3,866.35	.022
3,430 bbls. cement at $2.85	9,775.50	.055
2,718 cu. yds. sand and gravel at .90	2,446.20	.014
	$16,088.05	.091

A. A. Clark.

303 Tribune Bldg., Salt Lake City, Utah, Dec. 23, 1908.

Minneapolis Building Department Tests of Reinforced Concrete Columns.

Sir: I have noted your review of the tests of the Minneapolis Building department on reinforced concrete columns, also the remarks of S. E. Thompson and your editorial of Jan. 7.

The writer witnessed some of the tests of the building department. He also was very kindly presented by Mr. Cowles with a print showing the makeup of the set of columns. The department was hampered in its work, first by lack of equipment, second by the small size of the machine, which forced it to test small specimens. The efforts of the officials in this direction were commendable, however, in that they did the best they could.

The concrete used was hand-mixed, with a sand that was below the grade we usually expect to use in concrete work, and the concrete itself was below the standard used in general practice. In view of the fact that the specimens were small it was a difficult matter to design the reinforcement so that it would bear a fair proportion to the reinforcement of the full-size column. For example, ⅛-in. round vertical rods supported by hoops 6 ins. on centers would have about as much restraining effect on concrete against lateral bulging as ordinary 1⅛ or 1¼-in. rods would have with hoops 2 ft. on centers, leaving us rather slim ground upon which to make a legitimate comparison between spirals and hoops.

The majority of tests which the writer has seen using hoops alone apparently bear out the view of Mr.

Thompson and the Editor, the hooped columns, however, presenting lateral flexibility to a surprisingly high degree. Such a column commences to check and scale outside of the hooping before it has developed more than half of its ultimate strength, in strong contrast with the longitudinally reinforced type, which gives little warning before it goes to pieces.

The combination of the two types of reinforcement, namely a fair degree of vertical steel and suitable hooping presents different characteristics under test. Checking and scaling of the outside shell does not take place until after the hoops are over strained and stretched. This scaling and checking does not occur until after the column has developed something like 85% or more of its ultimate strength. In view of the fact that the column is held in line more rigidly longitudinally by the vertical reinforcement there is no chance for the lateral deflection of the hooped type without the vertical reinforcement, with the result that the large distortion of the hooped type does not occur until the ultimate value of the column has been nearly developed.

The writer has made some tests up to a capacity of 700 tons, since he is doing such an amount of this class of work that he cannot afford to be in doubt as to the values developed. If Mr. Thompson can figure how he can obtain results secured by the writer in tests made by him (some of which are illustrated in Bulletin 11, Turner System of Reinforced Concrete) other than by figuring the combined effect of the vertical steel and the hooping he is doing much better than the writer is able to and certainly well deserves the thanks of the profession for the ingenious explanation that he will be forced to offer.

It seems to the writer that we cannot get good results in a reinforced-concrete column without proper attention to the makeup of the concrete, the hooping and the vertical reinforcement, any more than our best bridge engineers succeed in developing the desired strength in bridge compression members without proper arrangement of the steel and proper attention to the proportions of the section and the size of the lacing in the makeup of the member.

In this respect the writer would disagree with Mr. Cowles in his conclusions regarding the relative efficiency of welded hoops and spirals.

Respectfully yours,

C. A. P. Turner.

Phoenix Bldg., Minneapolis, Minn., Jan. 9, 1909.

Diagram for Reinforced-Concrete Beams According to D'Ocagne's Method of Isoplethe Points.

Sir: Many tables have been published for use in designing reinforced-concrete slabs and beams but it may be said of all of them that they cover too much paper, but do not cover a very wide range of values. The accompanying diagram, which is constructed in accordance with d'Ocagne's method of isoplethe points* and which gives results that are accurate for all practical purposes, is compact and may be made to cover all values of the various variables.

In constructing the diagram the "straight line" formula was used. All the columns are self-explanatory except the first and the last.

$$f_s\ (T,\ c,\ n) = \frac{c^2 n}{2T\ (T + c\ n)}$$

and is the constant K_1 in the formula $A = K_1\ b\ d$;

$$f_m\ (T,\ c,\ n) = \frac{n\ c^2 (3\ T + 2\ c\ n)}{6\ (T + c\ n)^2}$$

and is the constant K_2 in the formula $M = K_2\ b\ d^2$.

T = Allowable stress in steel.

c = Allowable stress in concrete.

n = Modulus of elasticity of steel. / Modulus of elasticity of concrete.

A, M, b & d as on diagram.

The lines at the top of the diagram are intended as a key for its use. For a simply supported beam uniformly loaded the moment may be obtained from the diagram. For other cases, the moment must be calculated or the load multiplied by the proper factor to permit the use of the diagram to obtain the moment. Suppose we want a simply supported beam with span of 19.5 ft. to carry a load of 600 lbs. per lin. ft. Allowable stresses T = 15,000 lbs. per sq. in., c = 500 lbs. per sq. in. and n = 15. Place straight edge on 600 on "Load" line and 19.5 on line "d" (see line 1). Swing about point of intersection on line "M" until straight edge is on point 15,000-500-15 on line "f_m (T, c, n)." Then swing about point of intersection of this line with line "$b\ d^2$" until you get any desired depth and width as b = 10 ins. and d = 21.5 ins. Now swing about point of intersection with line "$b\ d$" until straight edge is on point 15,000-500-15 on line f_s (T, c, n) and read on line "A" 1.2 sq. in. area of steel required.

The diagram is particularly useful in cases where there are limitations placed on the design and which would ordinarily be solved by several trials. For instance, it is desired to design a reinforced-concrete slab not to exceed 6 ins. in thickness and to take a moment of 30,000 in. lbs. Place straight edge on 12 on line "b" (see line 2) and 5½ ins. on line "d" (½ in. allowed for covering steel). Swing about point of intersection with line "$b\ d^2$" until it crosses 30 on line "M." The intersection of this line with line f_m (T, c, n) will give stresses to be used. It will be safe to use any of the values falling above this line. We will take 12,500-500-15. Then, to get area of steel, place straight edge on point of intersection of the first line with line "$b\ d$" and point 12,500-500-15 on line "f_s (T, c, n)" and read on line "A" .49 sq. in.

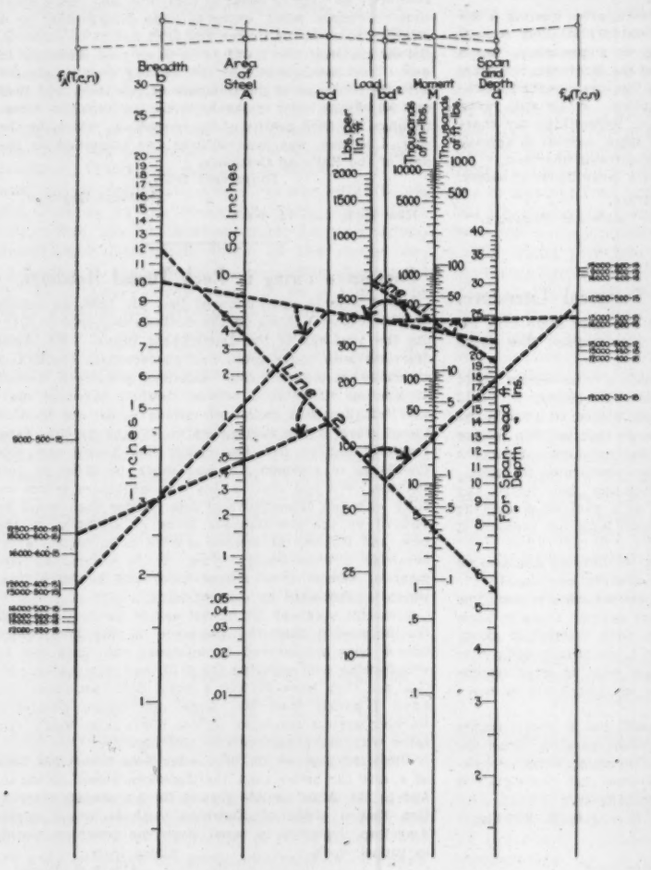
If it is desired to use values of T, c and n other than those given on the diagram, the corresponding points on the lines "f_s (T, c, n)" and f_m (T, c, n)" may be found by calculating a numerical problem with the desired values of T, c and n and using the diagram backwards.

Yours respectfully,

L. H. Nishkian.

1262 Turk St., San Francisco, Cal., Dec. 4, 1908.

*[This method has been fully described in its application to other cases in Engineering News, issues of Feb. 8, 1906, p. 157; May 31, 1906, p. 612; Dec. 19, 1907, p. 682; Sept. 3, 1908, p. 250.—Ed.]



REINFORCED-CONCRETE BEAM DIAGRAM.

Graphical Comparison of Steel Column Formulas.

Sir: A paper entitled "Safe Stresses in Steel Columns" presented last February before the American Society of Civil engineers by Mr. J. R. Worcester, M. Am. Soc. C. E., brought forth a discussion showing a wide range of opinion on the subject. The author proposed a new column formula based on tests of "full-size" columns made by Tetmajer, Marshall, Christie, Bouscaren, Strobel, Lanza and the Watertown Arsenal, with a maximum compressive value of 12,000 lbs. per sq. in. at zero ratio of l to r and decreasing by an elliptical curve to zero at a maximum ratio of l to r equal to 120. He based his limiting value of compressive stress of 12,000 lbs. largely on the fact that steel in compression does not develop the strength of the tension specimen test-piece, and fixed a maximum ratio of l to r of 120 as "warranted by experiments and good practice."

As pointed out by Mr. Carpenter and others in the discussion, however, the tests made by Tetmajer, Marshall and Christie were on small bars, angles and other shapes and tubes and the full-size tests of Bouscaren, Strobel and the Watertown Arsenal were [illegible]ly on wrought-iron columns, made many years [illegible]o. He further adds that there is a lack of data on [illegible] elastic strength of columns, but that such as he ha[illegible]n able to find indicate that the elastic strength w[illegible] found below that of test specimens, but not mor[illegible]o than with eyebars in tension.

In the light of the Quebec Bridge disaster, [illegible] knowledge the engineering profession most needs [illegible] addition to tests of full-si[illegible]sections similar to those [illegible]ed on the Quebec and [illegible]nsboro bridges) is exhau[illegible]ve tests of full-size comm[illegible]al column sections of [illegible]al proportions, well desi[illegible]d as to details, of materi[illegible]s known as "railway bridge steel," with an ultimat[illegible] tensile strength of from [illegible]00 to 65,000 lbs. per sq. [illegible]as per the revised Manu[illegible]turers' Standard Specifica[illegible]ns, and of first-class workmanship as obtained by using modern methods in a shop equipped with modern tools such as are found to-day in our leading bridge shops.

The great variety of framed structures which the bridge and structural engineer is called upon to design, ranging from heavy railway bridges with compression members having comparatively small ratios of l to r to light transmission towers where main compression members having ratios of l/r = 200 are of frequent occurrence, calls for a column formula of considerable flexibility which, as pointed out in the discussions of the paper previously referred to, is not "chopped-off" at the long end; for a simple clause could be inserted in the specifications limiting the permissible maximum ratios for the various types of structures. As cited by Mr. Coombs, we must not lose sight of the fact that probably more full-size tests have been made of transmission towers than that of any other type of framed structure, showing remarkable ability to withstand compression at very high ratios of l/r.

In the investigation of present structures, where ratios of l/r far in excess of Mr. Worcester's limit are frequently found, such a formula would be of no value. Its adoption by any of our leading bridge or structural companies would make the securing of work on a competitive basis a very difficult matter indeed. Engineers would hardly feel justified in advocating this increased cost to their clients, and in fact, with the various building laws of our principal cities fixing the permissible unit-streases for steel columns, it is hardly likely that capitalists would consider any reduction. For competitive designs, however, a formula is almost imperative, and the question then is which of the leading column formulas should be adopted until exhaustive tests shall furnish the profession a more accurate one. The following graphical table is therefore submitted, showing the leading formulas for the strength of steel columns between the ratios of zero and 200.

In comparing over forty bridge specifications of the leading railroads of United States and Canada, it was found that a large percentage of them used either the straight-line formula 16,000-70 l/r of the American Railway Engineering and Maintenance of Way Association, or the well-known Gordon formula in the form $\frac{17{,}000}{1 + \frac{l^2}{11{,}000\ r^2}}$ for medium steel and $\frac{15{,}000}{1 + \frac{l^2}{13{,}500\ r^2}}$ for soft steel (some of the specifications however not making any distinction between the two grades). The percentage would have been greater had more of the roads used an impact formula instead of a permissible live-load unit-stress about 50% of the above without impact. A list of various roads using the above formulas is given on the diagram, but there are doubtless more roads using them. It is evident, therefore, that a large percentage of the steel bridges standing today, many of them carrying

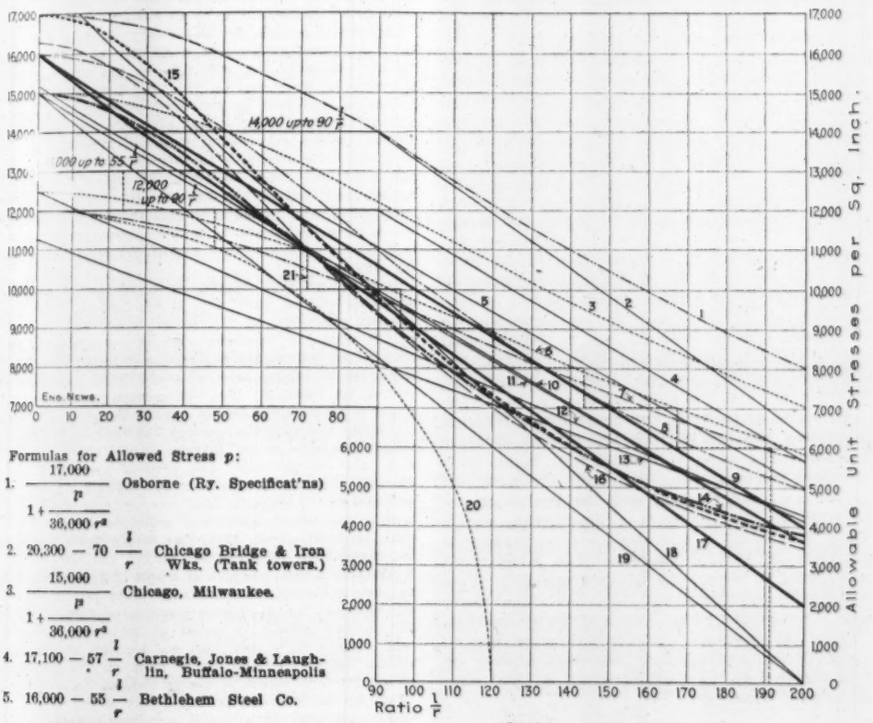
satisfactorily much greater loads than those originally intended, have been designed under the above formulas.

The diagram clearly shows the wide variation in current practice. If the formulas adopted by the Osborne Engineering Co. and the Chicago Bridge & Iron Works are safe and according to good engineering practice, then the formula proposed by Mr. Worcester is far too conservative and would add unnecessary material and expense to the structure. In fact, in his discussion of Mr. Schneider's excellent paper on "The Structural Design of Buildings," Trans. Am. Soc. C. E. Vol. 54, p. 418, he proposed an alternate rule for compression in place of the straight line formula 16,000-70 l/r, as follows: "Columns may be used with a ratio of l to r not exceeding 16, l being expressed in feet and r in inches (equivalent to a maximum l/r of 192). The unit-strains shall be 13,000 lbs. per sq. in.; for l/r from 2 to 4, 12,000 lbs. per sq. in.; from 4 to 6, 11,000 lbs. per sq. in.; with a decrease of 1,000 lbs. for each succeeding increase of 2 in the ratio of l to r, which, he adds, "would give in every case safe results and be much easier of application." The result of this rule is plotted in the diagram and is shown by the stepped line. It will be noted that this rule admits of far greater values than his conservative elliptical formula and permits of a maximum ratio of l/r of 192 with a permissible compressive stress of 6,000 lbs. per sq. in., instead of zero value at only 120 ratio.

In the light of our present knowledge the straight-line formula 16,000-70 l/r of the American Railway Engineering and Maintenance-of-Way Association seems to be best suited to meet the various needs of current practice and is rapidly gaining favor with those of the profession engaged in the design of framed structures.

Joseph G. Shryock, Assoc. M. Am. Soc. C. E.

Philadelphia, Pa., Dec. 17, 1908.



Formulas for Allowed Stress p:

1. $\dfrac{17{,}000}{1+\dfrac{p}{36{,}000\,r^2}}$ Osborne (Ry. Specificat'ns)
2. $20{,}300 - 70\,\dfrac{l}{r}$ Chicago Bridge & Iron Wks. (Tank towers.)
3. $\dfrac{15{,}000}{1+\dfrac{p}{36{,}000\,r^2}}$ Chicago, Milwaukee.
4. $17{,}100 - 57\,\dfrac{l}{r}$ Carnegie, Jones & Laughlin, Buffalo-Minneapolis
5. $16{,}000 - 55\,\dfrac{l}{r}$ Bethlehem Steel Co.
6. $\dfrac{12{,}500}{1+\dfrac{p}{36{,}000\,r^2}}$ Cambria, Carnegie, Jones & Laughlin, Phoenix Bridge Co.
7. $\dfrac{12{,}000}{1+\dfrac{p}{36{,}000\,r^2}}$ Boston.
8. $\dfrac{16{,}000}{1+\dfrac{p}{18{,}000\,r^2}}$ Dominion Government.
9. $16{,}000 - 60\,\dfrac{l}{r}$ J. A. L. Waddell ("De Pontibus").
10. $15{,}200 - 58\,\dfrac{l}{r}$ New York City, Washington National Board Fire Underwriters.
11. $15{,}000 - 57\,\dfrac{l}{r}$ Passaic Steel Co.
12. $12{,}500 - 42\,\dfrac{l}{r}$ C. E. Fowler ("Steel Roofs & Buildings").
13. $11{,}300 - 35\,\dfrac{l}{r}$ H. E. Horton.
14. $\dfrac{15{,}000}{1+\dfrac{p}{13{,}500\,r^2}}$ Chesapeake & Ohio Ry., Norfolk & Western Ry., Phila. & Reading Ry., Pennsylvania R. R.
15. $\dfrac{17{,}000}{1+\dfrac{p}{11{,}000\,r^2}}$ American Bridge Co., Baltimore & Ohio Ry., Chesapeake & Ohio Ry., Long Island R. R., Deepwater Ry., Phila. & Reading Ry., Virginia Br. & Iron Co.
16. $\dfrac{16{,}250}{1+\dfrac{p}{11{,}000\,r^2}}$ Philadelphia.
17. $16{,}000 - 70\,\dfrac{l}{r}$ Am. Ry. Eng. & M. W. Assn., Boston & Maine Ry., Canadian Pacific Ry., Grand Trunk Ry., Maine Central Ry., Mo., Kansas & Texas Ry., Nash., Chatt. & St. L. Ry., N. Y., N. H. & H. Ry., St. Louis & San Fran. Ry., St. Louis & Southwestern Ry., Wabash Ry., M. S. Ketchum ("Steel Mill Bldgs."); C. C. Schneider ("Structural Design of Bldgs.").
18. $18{,}000 - 90\,\dfrac{l}{r}$ Southern Ry.
19. $15{,}000 - 75\,\dfrac{l}{r}$ L. D. Rights.
20. $12{,}000\sqrt{1-\dfrac{p}{(120\,r)^2}}$ J. R. Worcester.
21. Rule, J. R. Worcester.

GRAPHICAL COMPARISON OF THE LEADING FORMULAS FOR STRENGTH OF STEEL COLUMNS.

Lectures on the Conservation of Natural Resources.

Sir: The reference, in the illuminating article by Mr. J. P. Snow in the issue of the Engineering News for Dec. 3, 1908, to the consternation of the sawyer at the loss of water through evaporation has been well illustrated at a local mill during the past summer of deficient rainfall. In the early part of the forenoon there was plenty of water in the brook to run the mill, but after the sun had a chance to get in his "pumping action" it was necessary to stop the mill because of lack of water. This happened many days in succession.

The discussion of late in regard to forest, as well as other, conservations has been very instructive and beneficial to those who have had access to sane and authoritative articles upon it. That number is comparatively small, however, and it would seem that there is a necessity for broad dissemination of information which especially affects the section of the country reached. It would seem that the Federal Government might with great effectiveness undertake an extensive series of lectures illustrated by lantern slides and in other ways. The particular problems of each section of the country should be dealt with by those familiar with that part of the country. The lectures might be given by experts from the U. S. Geological Survey, U. S. Department of Agriculture and other departments as well as state and other authorities. The lectures could at the same time distribute pertinent literature on the subject which is published by these departments and elsewhere.

Such information given before students in colleges, academies and high schools, in rural lecture courses and various other places would give a lively appreciation of the necessity for intelligent and enthusiastic cooperation in order to conserve the natural resources and thus secure the advantages which would follow. With a people thus enlightened proper laws and proper practice would be forthcoming.

Such a series of lectures delivered by Mr. Philip W. Ayres, State Forester for New Hampshire, before the students of the Thayer School of Civil Engineering, Amos Tuck School of Administration and Finance and Dartmouth College and residents of Hanover gave very valuable information and aroused much enthusiasm. The illustrated lectures given by a thoroughly informed lecturer in a delightfully effective and enthusiastic manner were supplemented by a tramp through the woods, during which time additional and supplementary information was given.

Yours truly,

Charles A. Holden.

Hanover, N. H., Jan. 8, 1909.

The San Francisco Water-Supply and the Yosemite National Park.

Sir: I thank you for your courtesy in sending me a copy of your editorial article [Jan. 7, 1909] relating to my opposition and that of many others to the Garfield grant to San Francisco of large portions of the Yosemite National Park for a water-supply. Among the "others" I may mention the Sierra Club of that city, the American Civic Association and the Historic and Scenic Preservation Society, both national organizations, and the Appalachian Mountain Club of Boston.

If you were more familiar with the opposition to this scheme and with the grounds on which the opposition is based—as set forth in the printed record of the hearing of Dec. 16, 1908, before the Public Lands Committee—you would not charge myself and other opponents with taking up the cudgels in behalf of the Spring Valley Water Co. I have no interest of any sort, pecuniary or other, in that company and don't care a straw about it. What I am interested in is to help block the wanton destruction of the Hetch Hetchy Valley—one of the most beautiful of God's creations. In this matter I have taken up the cudgels in *your* behalf and that of every other American citizen who does not wish to see the good of the whole people subordinated to the interests of a portion.

I am glad to see that you admit that I am right in stating (1) that the Spring Valley Water Co. is not a monopoly in the sense of fixing its own water rates, and (2) that this scheme is being used to bring that company to sell out to the city. I have not said that this is wrong; but only that it implies a lack of sincerity on the part of the promoters.

You are in error in saying that the opponents are all "far-easterners" except Mr. Muir. The votes against the measure numbered over five thousand in San Francisco, and the fight against the scheme is led by the officers of the Sierra Club. But as it is your park and my park and the public's park, why should we not have a right to be heard?

You are in error also in saying that I have not been in the Yosemite Valley. I have also been over a large part of the drainage area affected by this grant, and had the honor to originate the Yosemite National Park, as Mr. Muir will tell you, for he and I set on foot and promoted the measures which resulted in its establishment. I was the only person who appeared before the Public Lands Committee of 1890 in advocacy of its creation, and I have been fighting for its integrity ever since.

Now, assuming that you are right that the Spring Valley is a monstrous monopoly, this is not the point at issue at all. That point is that the Hetch Hetchy is not necessary to San Francisco, for it has many other available sources. In the San Francisco municipal reports for 1877 you will find a report by Col. G. H. Mendel, U. S. A., of over 200 pages in which he reports on *fourteen available sources*. Offers to the city have been made within a year of three separate sources: the Feather River, the South Fork of the American and the Stanislaus (the latter by two parties) and Mr. Muir has suggested the Cherry Creek region north of the National Park. Nothing could justify the destruction of the Hetch Hetchy Valley but an overwhelming necessity, proved by an impartial investigation. Since Mendel's time the city has made no such impartial investigation. Secretary Garfield has made none—says he has no need to make one; and certainly Congress has made none.

Nor has the Secretary investigated the resources of Spring Valley. I know nothing of the facts, but I know the company's published claims:

(1) That it can develop its present territory to 100,000,000 gals. per day. This is substantially confirmed by three competent engineers: Col. Heuer, U. S. A., Mr. Grunsky and Mr. Davidson, of the U. S. Coast and Geodetic Survey. (The present capacity is about 36,000,000 and the present demand about 32,000,000.)

(2) That it can develop other territory on which it has options so as to bring the total delivery up to 250,000,000 gals. per day. Moreover, it offered, if it could come to terms with the city for the purchase of its property, to turn over these options free of charge. And if I mistake not, it agrees to fix the price by arbitration. Now, even bad men sometimes have good things to sell and they are not to be considered bad simply because the price they ask may be, or may be thought to be, too high. High or low, it is certain that the Merchants' Association of San Francisco, on a test vote, declared itself overwhelmingly in favor of the purchase of the Spring Valley properties.

Is it too much to hope that this explanation may lead you to a fuller consideration of the merits of the question, and that you may be found on the side of the whole people in their fight for this wonderland of Nature, and the public's rights therein, as guaranteed by the unanimous vote of Congress in 1890, by which it was intended to rescue this region from all forms of spoliation.

Respectfully yours,

R. U. Johnson,

Union Square, New York City, Jan. 11, 1909.

[In the note to which Mr. Johnson refers we took particular pains to give him credit for his work in securing Yosemite Park for the United States and also for the sincerity of his motives in opposing what he regards to be a serious threatened curtailing of both the beauty and usefulness of a portion of the Park. We made no plea for the surrender of this or other national reservations for any utilitarian purpose that would prove to be their virtual ruin, but we did say that

on the face of it there appears to be no reason why a storage reservoir in any one of the great national parks might not add to rather than take from both their attractiveness and utility.

We put forth the statement just quoted largely as a challenge, in the hopes of eliciting something from Mr. Johnson or some one else of like mind which would be more specific than broad general assertions that to grant the Hetch Hetchy lands to San Francisco for water-supply purposes (in exchange for other lands now held by that city) would annihilate all the beauties of one of the chief portions of the Park, besides excluding visitors from a large area of the Park. It is only fair to presume that Mr. Johnson has specific information on this point in the way of maps and photographs, and if he or any one else has such or any other pertinent information we shall be pleased to give a reasonable amount of space to its presentation in our columns.

We continue to be of the opinion that when Mr. Johnson changes from a defense of the Park to a discussion of the water-supply needs of San Francisco and the relations of the Spring Valley Water Co. to the city and to the control of water rates he seems to be venturing on uncertain ground and to be making himself, "presumably without intention, the champion of the water monopolists."

We regret that we did Mr. Johnson the wholly unintentional injustice of spreading the story that he had never set foot in the Yosemite Park, but we took pains to give our authority for that statement, which was a newspaper account of Mr. Johnson's recent remarks before a Congressional committee.

We did not make the admissions claimed by Mr. Johnson in the third paragraph of his letter. An unfortunate typographical error (unpardonable, we admit, in the eyes of one of the editors of "The Century Magazine") did make us say that

to all intents and purposes the Spring Valley Water Co. does *not* fix its own rates,

but the context showed that the "not" should have been omitted.

Nor did we admit (or in this case deny) that the Hetch Hetchy scheme is being used to force the water company to sell to the city. We only asked, in commenting on Mr. Johnson's assertion that the city was so using the scheme, "why shouldn't it do so," exactly as Mr. Johnson asks why he shouldn't fight to keep the city out of the Park.

As to whether or not the Hetch Hetchy is necessary to San Francisco, or if not necessary then enough cheaper and better than any other scheme to warrant San Francisco in trying to secure it, we are unwilling to accept so general a reference to a report made thirty years ago, nor the offers of private parties claiming control of other sources of supply, nor (worse yet) the claims of the Spring Valley Water Co. itself. The point is that the city authorities of San Francisco, acting on engineering advice, decided in favor of Hetch Hetchy, and their reasons for doing so should be given full and fair consideration. Moreover, the people of San Francisco, by a vote of 6 to 1, declared for both municipal ownership and the Hetch Hetchy scheme, as we understand it, on Nov. 12, 1908. How many of the small minority (5,000) who voted "no" did so because of their interest in the Hetch Hetchy scenery and how many voted "no" because they were against municipal ownership or for the local water company, we cannot say, but we take it that a large proportion of the negative votes had no relation whatever to keeping the city out of the reservation.

We are not only willing but urge that the interests of the whole people be considered in connection with the Hetch Hetchy scheme, but it should be remembered that the people of San Francisco are a part of the whole and that San Francisco has claims on the natural resources of California, such as water for municipal needs, that may be paramount to the claims of the rest of the country on the right to have maintained inviolate a choice bit of landscape. Moreover, as already intimated, we have seen no proof that the Hetch Hetchy landscape will be damaged by constructing a reservoir in the valley.

There is a broad view of this whole subject which should not be lost sight of by the most ardent friends of our national parks and reservations. If these vast segregated areas are not wisely administered, with due regard to state and local demands on their natural resources, the acquisition of further areas and the proper maintenance of those already set aside will be threatened. It is, after all, but an infinitesimal part of the whole population of the country that will ever see the wonders and the beauties of Yellowstone, the Yosemite or any of the other great national parks or the great forest reserves that have been carved out of national or state domains. The water, the timber and the minerals of these regions must be kept available for proper use, and to that end the people of the vicinity will always have a first claim, and a claim that may, conceivably, require occasional sacrifices of natural scenery. The government authorities to whom the administration of these national reservations has been entrusted have wisely recognized these claims of the local public.

Since the preceding paragraphs were written we have received much information bearing on this controversy, to some of which we will refer in a later issue.—Ed.]

More Concerning the Proposed $500,000,000 Expenditure on Waterways.

Sir: The editorial in your issue of Dec. 31 in which you criticise my statement that if $500,000,000 were spent in improving our waterways, as advocated by the National Rivers and Harbors Congress at its recent convention in this city, it would save the people of the Union fully half a billion dollars annually in reduced freight rates, has been called to my attention.

You devote nearly a column to a discussion of the subject, including the proposed Waterway Bond Issue of $500,000,000, and draw the deduction that my statements are misleading.

Replying to a letter of Mr. Weller in the same issue, you say:

Congressman Ransdell, the President of the Rivers and Harbors Congress, is doubtless sincere in setting forth the enormous profits which the United States can make by investing in waterways but as we have shown on our editorial page in this issue, his figures of profit are seen to be absurd as soon as they are critically examined.

Now, let us make a "critical examination" and allow the facts to speak for themselves.

You say "it is far from probable that freight can be carried by water routes on the average at *half the cost per ton per mile as by rail.*" In my judgment, you are wrong. Freight can be carried on well improved waters such as the Great Lakes, Long Island Sound, the Hudson River, and the Lower Mississippi River [illegible] *sixth the average cost by rail.*

According to official reports of the United [illegible]ateers the commerce through the Sault St. [illegible]e Canal during the season of 1907 was 58,217,214 [illegible] which was carried an average distance of 828.3 [illegible]s at a freight charge of 0.80 of 1 mill per ton per [illegible], equal to $38,475,345.

During the same year the average cost [illegible] moving freight by rail according to the Interstate [illegible]mmerce Commission was 7.59 mills per ton per mile, [illegible] times as much per ton per mile as the water rate [illegible]gh the "Soo." Had this lake commerce been carried [illegible] same distance by rail at average rail rates, the fre[illegible] charge instead of being $38,475,345 would have been [illegible]s times that sum, equal to $364,844,832, or $325,387 [illegible] in excess of what was actually paid. Hence, it is [illegible] to assume that the money expended by our gov[illegible]ment in improving the lake harbors and connecting [illegible]hannels through the St. Marie and Detroit Rivers, th[illegible]by rendering this splendid commerce possible, saved the American people in 1907 on that portion of the [illegible]mmerce passing through the Soo the sum of $325,387,[illegible] in reduced freight rates.

Moreover, there is a vast commerce on the Five Great Lakes which does not pass through the "Soo," and is carried at relatively the same rate of .80 of 1 mill per ton per mile—*less than one-ninth of the average rail rate*—the annual saving on which amounts to over a hundred million dollars.

We have no accurate statistics as to the freight rate and volume of business on the Ohio and Lower Mississippi rivers, but according to an elaborate study and estimate made in 1905 by Major Wm. L. Sibert of the U. S. Engineer Corps, now a member of the Panama Canal Commission, it cost 0.76 of one mill per ton per mile to move coal on the Ohio from Pittsburg to Louisville that year in the very unsatisfactory condition of the river, when it was navigable only for a few months of each year and at uncertain periods, and 0.67 of a mill from Louisville to New Orleans. These rates are respectively about one-tenth and one-eleventh of the average rail rate. When you consider that it is nearly 2,000 miles from Pittsburg to New Orleans and that the water rates are one-tenth to one-eleventh of those by rail, it is readily seen how rapidly the savings run into big figures.

Rates on package freights on rivers and canals are somewhat higher than the figures shown above for *general commerce* on the Great Lakes and for coal on the Ohio and Mississippi, but they are nothing like one-half of the average rail rate; and from the best information obtainable after a careful study of the subject, I am convinced that our *average freight rate by water is about one-sixth the average by rail.*

In 1907 our railroads carried 236,000,000,000 tons of freight one mile at an average freight charge of 7.59 mills per ton per mile, and received therefor $1,175,000,000, according to reports of the Interstate Commerce Commission. I estimate that our internal waters, including the Great Lakes, and excluding all coast wise business, although the latter has been greatly benefitted by government expenditures, carried that year about 73,000,000,000 tons one mile at a cost of $78,000,000; and had this waterborne commerce moved by rail at average rail rates the freight thereon would have been $555,000,000, or $477,000,000 in excess of the amount actually paid. Hence, it is clear that we are now receiving an annual benefit in cheap water rates on the commerce of our internal waters of nearly $500,000,000 a year.

But this direct saving is only a part of the benefit. A large percentage of all past and prospective expenditures for waterways is for improving harbors on our seacoasts, such as Boston and New York, and at the mouths of great rivers like the Columbia and Mississippi, thereby permitting the entry and exit of much larger vessels. The larger the ship, the greater its carrying capacity and the cheaper its rates of freight. Vessels drawing 28 to 32 ft., and carrying 8,000 to 12,000 tons can and do carry freight very much cheaper than those drawing 22 to 24 ft. and carrying 3,000 to 4,000 tons. The ocean rates to-day on the immense steamers plying at our great harbors, which have been deepened to 30 ft. and more, are from one-third to one-fourth the rates of 25 years ago, when steamers drew only 22 ft. to 23 ft.; and this saving of 300 to 400% in transportation charges is directly due to the improvement of our harbors.

Moreover, railroad rates are materially cheaper on lines paralleling and close to navigable waters.

Now, we have expended during our national life less than six hundred millions on all our waterways, and as the resultant benefit in cheapened freight rates is certainly in excess every year of the total original cost of all these improvements, I think it fair to assume that an additional expenditure of $500,000,000 to further improve these waters, under a comprehensive, business-like system at the rate of about $50,000,000 a year for the next ten years, would result in a further saving, when completed, of an equal sum every year.

Permit just a few words about our German and English cousins. According to Mr. E. R. Conder, an English authority, although canals have fallen into disuse and

rivers are neglected, it *costs three times as much to convey freight by rail as by water in England.* Mr. O. Fischbeck, an eminent authority on the German waterways, in a recent work called "Modern Germany," gives the freight cost on the Oder at about 3.33 mills per ton per mile, on the Elbe about 2.50 mills, and on the Rhine about 1.8 mills; hence, as the commerce on the Rhine is much the largest, it is estimated that the average cost there is 2.25 mills per ton per mile, considerably higher, you see than here. But how about the comparison with rail there? Why, it costs by rail there in round numbers 11.7 mills per ton per mile in 1906, as compared with 7.6 mills here; so in Germany the average cost of transportation by rail is, in round numbers, five times as much as by water, with improved waterways, and three times as much in England with unimproved waterways.

In this connection, let me say that the friends of improved waterways are not antagonistic to railroads. We believe there is sufficient business for both and that in the marvelous development of our great Republic during the next decade the railroads and the waterways will be taxed to their fullest capacity.

Respectfully yours,

Jos. E. Ransdell,

President National Rivers and Harbors Congress.

Washington, D. C., Jan. 14, 1909.

[It is a very common mistake to make comparisons between unlike things and then draw conclusions therefrom. To compare average rates for water transportation on the Great Lakes and average rates for freight by rail over the whole United States is to compare two things wholly unlike. Water routes everywhere carry chiefly low class bulk freights which can be handled at the lowest cost and on which the rates are always low. Of the 58 million odd tons of freight carried through the Sault Canal in 1905 no less than *six-sevenths was iron ore.* Mr. Ransdell takes the average rates paid on such freight, all of it carried over a long haul, averaging as he states 828 miles, nearly all of it loaded and unloaded with the highest type of automatic machinery, so that the time of a vessel in port is cut down to the lowest limit, and he compares this rate with the average ton mile rate on all freight moved by rail in the United States. The Interstate Commerce Commission report shows that the average length of haul of a ton of freight on the railways in 1905 was 237 miles, as compared with the 828 miles of iron ore movement on the Great Lakes. The freight handled by railways includes all the high class merchandise freight. It includes the freight carried in small lots on the thousands of miles of branch line roads, with thin traffic. It includes the freight hauled over mountain ranges and deserts and into and through the remote sections of the country. And besides this the freight rate by rail *includes the cost of maintaining the roadbed and the interest and dividends on the investment necessary to build it.* The water rate used for comparison never includes the cost of improving and maintaining the waterways; yet this should be included if a fair comparison is to be made between rail and water transport—a comparison that can be relied upon as a guide in settling practical business questions.

Another thing that must never be overlooked in computing actual cost of either water or rail rates is the *volume* of traffic. Rates are phenomenally low on the Great Lakes because of the vast bulk of traffic to be moved. Suppose, though, that the vast ore deposit in the Mesaba range had not existed. Then the huge traffic, the low rates and the enormous saving which Mr. Ransdell figures would never have been possible. It will not do, therefore, to jump at hasty conclusions, and base claims for the saving made by waterways generally on the savings made by water transportation on Nature's beneficient gift, the Great Lakes.

We are not, of course, denying that the cost of water carriage on certain natural waterways, where favorable conditions exist, is less than the cost of transport by rail. The point we urge is that the difference in cost, when the two systems are compared *on the same basis*, is far less than is often claimed.

Another point which should not pass unnoticed is the claim that because present waterways, natural and improved, benefit the nation to the extent of $500,000,000 per annum (supposing this were true) an investment of $500,000,000 on further waterway improvements would save as much more.

The fact is that we have already done the most necessary and important things for waterway improvements. Almost all the places where a dollar invested in improvements yields a big return in benefit to transportation have been already covered. Most of our future waterway work must be done where the cost of the improvement will be large and careful figuring will be necessary to find whether the resultant benefit will pay good interest on the outlay.

As to the influence of deeper harbors and larger and deeper draft vessels on the cost of water carriage: if Congressman Ransdell will consult authorities, he will find that his estimate of the saving by deepening harbors is vastly in excess of the actual amount. Tables in Prof. Johnson's treatise on "Ocean and Inland Water Transportation" show that average rates of ocean freight fell from an average of about 105 in the years 1884-1888 to an average of about 80 in the years 1900-1903. Part of this decrease was due to a general fall in all prices.

As to the larger vessel being the cheaper carrier, this only holds true on the routes (comparatively few) where the volume of traffic is very great. It is quite probable that the most economical ocean carrier for freight service alone to-day, is under rather than over 10,000 tons; and on many ocean routes the 5,000 to 6,000-ton vessel pays better than a vessel of double the size.

We regret to be obliged to take a position in seeming opposition to Congressman Ransdell, for we believe he is sincere in the campaign he is making for waterway improvements, and we recognize the necessity for some such enthusiastic promotion. What we do urge is that zeal be tempered with discretion and that those who are making the campaign for improved waterways shall realize the necessity for expert advice in the matter. If the nation is led into extravagant expenditures on schemes which will prove disappointing and unprofitable, there will be a reaction and many really important works of waterway improvement will be certain to suffer.—Ed.]

Annual Meeting of the Indiana Engineering Society.

The 29th annual meeting was held at Indianapolis on Jan. 14, 15 and 16, the place of meeting being the assembly room of the Commercial Club. The first session was called to order about 2.15 p. m. on Jan. 14 by the President, Prof. W. K. Hatt, of Purdue University. The report of the Secretary, Mr. Charles Brossman, showed for Dec. 31, 1908, a membership of 200, and a cash balance of $232. The address of the President dealt in part with the history and work of the society, and also with certain possible lines of action for the future. He referred particularly to legislation dealing with such public matters as road construction, the protection of water supplies, etc., and suggested the appointment of a committee to endeavor to secure concerted action on the part of similar engineering societies in neighboring states. The absurdity of the present system of appointing county surveyors was also mentioned, and it was stated that many of these men are entirely incompetent professionally. He advocated higher qualifications for such positions, and as a result of his remarks a resolution was passed for the appointment of a committee to consider and report upon improvements in this direction.

A paper on "Instruction for Railway Apprentices" was read by Mr. Wallace (Lafayette), and dealt mainly with the instruction system for shop apprentices on the New York Central Ry. Mr. E. E. Watts (Princeton) referred to the system tried at one time on the Illinois Central Ry. for instructing track apprentices. Mr. E. E. R. Tratman (Engineering News) pointed out that in the former case the aim is to educate young men as skilled workmen, while in the latter case the aim was to educate young engineers in the details of practical track work. The education of men as skilled laborers in track work has hardly been attempted, since this work is still commonly regarded as not requiring skilled labor. A brief report of the Committee on Surveying was presented by Mr. C. W. Appleby (New Albany).

The subject of highways was then taken up, and was opened by a paper on "The Modern Road Movement," by Mr. C. A. Kenyon (Indianapolis). He stated that while it is often remarked that roads in European countries are better than those in this country for the reason that the former countries have been building them for hundreds of years, yet as a matter of fact the modern roads are less than 100 years old, since Macadam and Telford only began their work in the early part of the last century. He referred to the great interest taken by European engineers in road improvement, but failed to explain that hundreds of these engineers are officially engaged in the building and care of roads, while in this country the number is extremely small. The great increase in automobile traffic and the very destructive influences of such traffic have, in Europe and in this country, put an entirely new aspect to the road maintenance question. Macadam construction seems quite unable to withstand these influences, and the plan of sprinkling tar or other compositions upon a finished road is little more than a dust preventive, as it cannot strengthen a macadamized road. Asphalt-concrete systems af various kinds appear to offer a solution of the problem. In one foreign system, the stone is mixed with tar at the quarry, and then shipped, laid and rolled cold. He had not thought this could be practicable, but it has given very good results. The paper reviewed the state-aid road systems employed in several states. Mr. Kenyon followed his paper with the report of the Committee on Roads and Pavements, in which was discussed the fallacy and poor results of the long-term guarantee system for paving contracts. The practices of allowing contractors to bid upon their own specifications, and of allowing property owners to decide what paving shall be used on a street were also referred to as unsatisfactory. Road repair work on country roads usually consists of dumping wagon loads of gravel in the middle of the road and leaving it for traffic to spread and consolidate. Mr. M. H. Downey (Anderson) read a paper on "The Three-Mile Road Law." This law was passed in 1907 and is so strongly objected to as unjust and discriminating that it is likely to be repealed. It permits the improvement of country roads with brick paving for a distance of three miles from a town, but the system of payment is considered very inequitable. In some cases its application has been defeated by opponents claiming that brick is not a suitable material for country roads.

The report of the Committee on Legislation urged that attention should be given by members and by the Society to such matters of pending legislation as stream pollution, road improvement, etc. This led to some discussion as to the advisability of the Society, as a body, taking active participation in such matters. The report of the Committee on Mining was brief, and related to the development of coal mining in Indiana. The case of mining by surface workings is responsible for much carelessness and inefficiency, but as deeper mining becomes necessary improved plants and methods are necessary for efficiency and safety. The last paper of this session was by Prof. R. L. Sackett (Purdue University) on "Gagings of the Wabash River at Lafayette, as Bearing upon the Problem of Conservation." The annual dinner was held in the evening. On the next day their was an excursion to the extensive new repair shops of the Cleveland, Cincinnati, Chicago & St. Louis Ry. at Beech Grove, near Indianapolis. These shops were only put in service last year.

At the morning meeting on Jan. 15, Mr. E. E. Watts (Princeton) made a report of progress for the Committee on Sewers, which committee is preparing statistics of sewers and drains in Indiana. A paper by Mr. F. A. Barbour (Boston, Mass.) on "The Work of the Royal Commis-

sion on Sewage Disposal in England," was read in abstract by Prof. Hatt. It contained a digest of the work and of the conclusions presented in the latest report. This matter has been presented already in our columns. Stress was laid on the necessity of preliminary treatment to remove solid matter. A short paper on "The Sewage Problem in Indiana" was then read by Mr. Charles Brossman (Indianapolis), and was followed by one on "Maintenance of Sewage Disposal Works," by Prof. Sackett. It related mainly to plants of the smaller class, which do not receive the same amount or degree of attention as the larger and more important plants. In the former, ease of maintenance should be aimed at, even at the sacrifice of efficiency. In designing small plants also, it is a bad mistake to ignore the kind of attention the plant will receive and the degree of purification which is called for by local conditions. Mr. E. E. Watts instanced cases of the neglect of proper maintenance. Prof. Sackett also showed a number of views illustrating the serious pollution of White River. This pollution is felt for 60 miles below Indianapolis, and is not only a menace to health but has reduced the value of farm property along its banks by the vile odors due to the pollution of the water and the putrefaction of animal matter, etc., that lodges on the shores.

An extremely interesting paper was then read by Dr. H. E. Barnard (Indianapolis) on "Pollution Problems of Lower Lake Michigan." Along this part of the lake (south of the Illinois and Michigan state lines) there are several cities and manufacturing plants which discharge their sewage and waste into the lake, and draw their supply from the lake. The seriousness of the problem is increasing rapidly, owing to the industrial development of this section. The typhoid fever rate was discussed in this connection. It has been assumed in several cases that uniform currents protect the water intakes from the access of polluted water. As a matter of fact there are no positive currents, and the course of the sewage varies with the wind. This has been proved by the government surveys, and is shown by a study of the course of a sewage of peculiar color discharged from a glucose plant. A series of samples of the water have been taken at points one mile apart on lines running several miles out into the lake. The results of these were shown on charts. Recently it was almost impossible to use the lake water in Hammond, owing to the strong pollution from sewage from a glucose plant. The charts show that the sewage tends to flow continually around the location of the Hammond intake. The normal bacterial count for the pure lake water is about 10; the observations noted above showed a range from 1,000,000 (near the Hammond intake) to 300 at a point five miles out. At Whiting, the count showed 100,000 at the sewer outlet and 80,000 at the water intake, indicating that four-fifths of the sewage was passing over the intake. The maximum count was 3,500,000. The remedy of these conditions is imperative, but can be effected only by concerted action on the part of the municipalities and states concerned.

Prof. Hatt called attention to the great importance of this matter, and referred to the extraordinary showing of the figures presented. The report of the Committee on Stream Pollution was read by Mr. C. C. Brown (Indianapolis), and stated that there is a growing interest in this subject on account of the damaging effect upon water supplies. The report reviewed a bill which is to be introduced at the present session of legislature, and which is for the purpose of protecting water for domestic use. It is similar to the Ohio law. It provides for eliminating present pollution, and makes it unlawful to build future plants discharging into streams unless they include a purification system approved by the State Board of Health.

A paper on "The Water Power of the St. Joe River" was read by Mr. A. J. Hammond (South Bend). This dealt with the hydraulic conditions of the river, its drainage area and stream flow, and the several dams, power plants and hydro-electric plants along its course. The river has a heavy fall and numerous rapids, and many cities along its course have been dependent largely upon the water power developed. A characteristic feature of the river is its uniformity of flow, making it particularly valuable as a water power stream. The minimum and maximum flow are about 1,000 sec.-ft. and 20,000 sec.-ft., but these extremes occur only in cycles of from four to six years. The extreme flood flow has been about 30,000 to 35,000 sec.-ft. The total drainage area is almost 3,900 sq. miles, with a mean annual rainfall of 35 ins. and a run-off of 12 ins., or practically 35% of the rainfall. The old dams gave heads of about 10 ft. for power purposes, but the 11-ft. head at Elkhart may be increased to 18 ft. by a new dam. At Berrien Springs, a new dam gives a head of 21 ft. for a power plant for electric railway work. This plant is peculiar in having each of the four 1,800-KW. generators directly connected to eight 54-in. Leffel water wheels built in pairs upon one shaft. The alinement, adjustment and thrust of the combination required very careful calculation and workmanship. The power is developed at 60 cycles, 2,300 volts; it is stepped up for transmission, and rotary converters at substations are used to distribute the power for railway use. The paper closed with a list of 11 power plants (two of which are proposed) on the river. They range from 1,000 HP. to 10,000 HP., and aggregate 40,000 HP.

A brief report of the Committee on Water-Works was presented by Prof. Sackett. The committee is investigating the use of a uniform system of accounting in order that reports may show commercial results. It will also have something to say on deep-well pumping. The air-lift system has been used extensively, but of late years there has been a development along the line of small centrifugal pumps inserted in 8-in. to 10-in. pipe wells. The efficiency of this latter system has not yet been determined.

At the evening session several papers were presented, none of which, however, brought out any extended discussion. The report of the Committee on Materials of Construction, presented by Prof. E. L. Hancock (West Lafayette), consisted largely of a review of the literature in this line published during the past year. It also included a statement of the output and processes of the several Portland cement companies of the state. A paper by Mr. E. Fillion (Mitchell) dealt with "The Manufacture of Portland Cement." A paper on "Short Span Bridges," by Mr. A. R. Holliday (Indianapolis), described different types of construction, including steel structures and concrete bridges reinforced by old rails, rods, and built-up reinforcing units. Prof. Hatt referred to the advantages of the latter system in eliminating the liability of improper placing of individual rods by careless or unskilled laborers, and also the trouble of wiring the rods together in the forms.

A paper on "Water Softening and Purification for Manufacturing Purposes" was read by Mr. M. W. Mix (Mishawaka). It reviewed the general purposes and economic results of such treatment in order to prevent the scaling of boilers and to make the water better adapted to various processes. Thus in a large laundry plant, the introduction of water softening apparatus has reduced the consumption of soap very considerably. The materials used in softening are usually soda-ash and lime, applied in different ways by different apparatus and varying, of course, with the character of the water in each case. A paper on "The Water Purification Works at Columbus, O.," was read by Mr. R. B. Wiley (Lafayette). These works are peculiar in that they provide for the softening and clarification of the city's water supply, the water of the Scioto River being hard and muddy. The water is treated in tanks, thence delivered to settling basins, and thence to clear water reservoirs. The plant has been in operation only a few months. In reply to Mr. Mix it was stated that the city investigated the question of providing a separate plant for treating water for manufacturing purposes, but found it more economical to treat the entire water supply.

In a paper on "A Comparison of Bridge Waterways," Mr. Daniel B. Luten (Indianapolis) compared the merits of rectangular and arched openings on the basis of waterway capacity and structural efficiency. He favored the arch span, and referred to concrete box culverts in which a central pier is introduced to support the roof slab, thus blocking the waterway. Even where ice and drift have to be passed, he considered the arch preferable. It is rarely economical to increase the waterway of an arched culvert by raising the arch; it is much more economical to do this by increasing the span. Mr. Luten presented also the report of the Committee on Bridges, which dealt principally with the defective design of some highway bridges having flat slab spans reinforced by I-beams. This type was called by its designer a "flat arch," although there is no such action in it. The report submitted a table of sizes of I-beams for various spans of such bridges. With the beams 3 ft. apart in each case, and with the concrete extending 2 ins. above and below the beams, the sizes range for 6-in., 12¼-lb. I-beams for the 5-ft. spans, to 20-in., 80-lb. beams for 28-ft. spans. A report on the use of concrete for buildings was also read, with a proposed municipal ordinance governing such construction.

At the closing meeting on Jan. 16, a large proportion of the papers were presented by members of the engineering staff of Purdue University. Prof. Hatt, however, first read a paper on "Reinforced Concrete Sewers" by Mr. F. R. Charles and D. B. Davis (Richmond). Mr. C. A. Tripp (Indianapolis) presented the report of the Committee on Electrical Engineering, and Prof. G. W. Case followed with a short paper on "The Behavior of the Magnetic Needle in Indiana." Prof. I. D. Hoffman presented a report from the Committee on Mechanical Engineering. Prof. L. V. Ludy described some tests of an automobile, which were made on the special plant built for this purpose at Purdue University. Two papers on Indiana coals were then read; the first was by Prof. Young and Mr. Heck, dealing with comparative tests of coals; the second, by Mr. G. W. Munro, dealt with the use of these coals in gas producers. In reply to a question, Mr. Munro stated that various fuels can be used in producers including spent tan-bark and charcoal. The latter, in its commercial state, however, usually contains too much tar for satisfactory use.

The election of officers resulted as follows: President, E. E. Watts, Princeton; Vice-President, C. C. Brown, Indianapolis; Trustees, W. K. Hatt and C. A. Tripp; Secretary, C. A. Brossman, Indianapolis.

Annual Convention of the National Association of Cement Users.

The field of the National Association of Cement Users, like that of all technical societies, is the bettering of the particular industry it represents by the interchange of opinion, the promulgation of standards and the advice of the more experienced to those not so fortunate, but in this association the field is so new, the possession of experience so limited and the standards so unfixed that the work is of extraordinary difficulty though of undoubted value. Originally started in 1904 as an aggregation of practical men interested in the concrete trade and hopeful of its future, it is gradually developing into an authoritative body on the use of cement in construction. But the end is yet far off. The proportion of skilled workers to skilled designers is still very large, and the larger problems of the material are still a closed book to most of the members on the floor of the convention. Happily, there is to be noticed a marked improvement in the tone of the meetings and the earnestness of the discussions could be well copied by much older organizations. The combination of the small concrete contractor with long experience in the peculiarities of the material with the more technical designer and constructor is advantageous to both and to the progress of the industry. One of the most important features of the convention is the "experience meeting"

which is held every morning from 9 to 10 before the regular session. In this meeting, the subject for which is assigned for each day, there is a free-to-all discussion which brings out many of the finer points in the actual construction and design that it is impossible to include in technical literature, and for the learning of which most of the members have no other opportunity.

As usual the fifth annual convention of the association, held this year at Cleveland, O., lasted throughout one week, from Jan. 11-16. It included seven regularly ordered meetings as well as three meetings for the reading of papers and for discussions passed over from previous meetings. In addition several separate sections on special topics were held. The long list of papers, discussions and reports were too extensive for even these 40 odd hours of meeting and some projected work had to be passed over. In addition to the technical sessions held at the Hollenden Hotel, the usual cement appliance and equipment exhibition was held at a nearby armory.

Technical Papers.

The President of the Association, Mr. Richard L. Humphrey, devoted the greater part of his annual address to the discussion of the fire loss of this country, which is far greater than that of any other country in the world. After quoting statistics to show the enormous losses due to flimsy and fire-trap construction, he stated that no other field of endeavor for the members of the association was as fertile as the advocating of good building laws, which would require the rational construction necessary to prevent the origin and the spread of conflagration. Not only would the saving by such laws be direct, in the preservation of such property as is now destroyed by fire, but also the saving on insurance rates would add greatly to the wealth of those who own buildings.

This year the main attention of the convention was devoted to two things; the artistic development of concrete design and the cost of its construction. This is a natural consequence of the present state of the concrete industry, for these two questions are the ones interesting to both the utilitarian and the esthetic sides of the opposition, or rather the doubting party. With the passing of the last few years even the most pronounced opponents to concrete have become convinced of its safety, provided the proper care is taken in its manufacture. This disposes of the first of the great faults found with the new form of construction. But it has been thought by many that the additional care necessary for a safe construction would make cost prohibitive and even where cost was of lesser importance the horrible examples of some concrete architecture has kept many from advocating it.

ART AND ARCHITECTURE.—One evening was entirely devoted to the answering of the charge of inherent ugliness in concrete. With the aid of lantern slides showing finished work, many examples of artistic constructions were given. First of these were from the report of the Committee on Art and Architecture, which was written and presented by Mr. Albert Moyer, of New York. This committee throughout the past year has been collecting from all available sources views of finished concrete bridges and buildings completed during the year, from which they awarded several prizes for excellence, purely from the artistic standpoint. Those structures winning prizes are to be illustrated in the coming annual report of the Association and nearly all of merit submitted were illustrated from the slide at the convention. The departure from conventional form, particularly in the high-class residences, is perhaps the most marked feature of those buildings which were illustrated. It seems sure that at last the sense of the material is being felt by a certain class of architects who are devoting their attention to this class of work. It should be highly gratifying to those who have been trying to develop a proper appreciation of artistic concepts in concrete design that at last some fruits of their lessons are becoming manifest.

Along this same line Mr. B. A. Howes, New York City, illustrated a number of all-concrete residences that he has built. These buildings, all of a higher class, have been of block, of plain and of reinforced concrete, the material being used throughout, even to the floors, fireplaces, staircases and interior decorations. Gradually a distinct type of design has been evolved in which the absence of sharp detail and complicated figures and the predominance of straight lines have been most prominent. As a rule, Mr. Howes has allowed the concrete to show for itself what it is and has resorted entirely to surface treatment for exterior decoration. For the isolated house in a wooded or suburban locality the type of residence shown ranks well up with any style of construction.

The work in casting stone by the firm of Emerson & Norris, of Boston, was illustrated in a lecture by Mr. Norris. For a considerable number of years they have been engaged in what they call the reproduction of stone so as to make it as near the natural product as possible. Their product is in no way to be confused with the rock-imitating concrete block. Instead they have mixed the ingredients that go to make up a natural rock in such a way as to make a replica of that rock in the rough and then have treated it with tools in the same manner as the natural stone would be treated. The work illustrated had a remarkably artistic value.

COST DATA.—Although nearly every paper contained some reference to costs, the main one around which most discussion hinged was by Mr. Leonard C. Wason, Boston, entitled "Cost of Concrete Construction as Applied to Buildings." This paper appeared in our issue of Jan. 14, 1909. Briefly, it outlined the method of cost keeping of the contracting company of which Mr. Wason is president and presented to some considerable extent, a tabulated list of costs of the various items that go to make up a reinforced-concrete building. It seemed to be the general opinion of the convention that while such figures are of undoubted use to the firm keeping them, they should be treated as rather rough estimates by others. This is not on account of any lack of confidence in the figures as given out, but because such figures are largely dependent on peculiar conditions not reducible to words and not capable of being explained. Location, climate, character of force and foreman, peculiarities of the owner and engineer and many other details, all enter into the cost of any structure and the relation of each to the total cost is difficult to analyze. As an example of the influence of certain elements, Mr. Wason said that on two jobs, freezing weather added about 5% to the cost of construction. However, such costs are invaluable to the firm that keeps them, not only in estimating for new work, but if kept at stated small intervals, as a constant check on the progress of construction. As one contractor said, "If the man on the job knows every week that the boss knows just how much the week's work cost, he is going to put in his best efforts, to keep that cost at a minimum."

The ordinary method of estimating concrete buildings in cost per cubic feet of contents was deprecated, because of the great influence of floor heights, spans, etc., upon such figures. Bearing this in mind, the figures given by Mr. Emile G. Perrot in a paper on "Comparative Cost of Reinforced-Concrete Buildings" may have some value. He cited one building, eight story and basement and used for heavy lithographic work, in which reinforced concrete effected a saving of about 20% over other suitable materials and another of a similar size, but for office purposes, in which 30% was saved. In conclusion he gave the following costs, in cubical contents, of concrete buildings, built by his firm:

Warehouses and factories	8—11 cts. per cu. ft.
Stores and loft buildings	11—17 cts. per cu. ft.
Miscellaneous, such as schools and hospitals	15—20 cts. per cu. ft.

These costs include the building complete, omitting power, heat, light, elevators and decorations or furnishings.

In his paper on "Cost of Concrete Bridges," Mr. Henry H. Quimby, Engineer of Bridges of Philadelphia, Pa., continued the idea of the unreliability of cost data unless all of the intimate details of the work are known. In part he said:

It is impracticable to select any unit of measure of a bridge and use it as a reliable basis for estimating cost. In a table covering 18 concrete arch bridges recently built in Philadelphia the concrete price spread upon the span area—the clear span by the width—varies from $3.11 to $9.74 per sq. ft., and it varies from $1.73 to $7.39 per sq. ft. of area occupied by the ground plan to ends of wings, the latter extremes being not on the same bridges as the other two. The average of the lot was $6.25 per sq. ft. of span area and $3.50 per sq. ft. over all, most of them being single span bridges with long wings, and all being highway bridges designed to carry loads of 40 tons on two axles 20 ft. apart. All have ornamental concrete balustrades and washed granolithic surfaces and paved decks, with electrical conduits and manholes, and water pipe and sewer well-holes, and some have pretty deep foundations. If the whole contract price be set against the yardage of the concrete in the structure the unit costs vary from $8.50 to $11.25 per cu. yd., averaging $9.75.

It is found that in the circumstances under which the bridges referred to were built steel plate-girder bridges will cost more than concrete arches, the differences being considerable. Several opportunities for fair comparison have made this clear, as great a difference as 25% of the higher being indicated. This saving is in the first cost, any if we add the capitalized cost of proper maintenance of the steel structure—which seems to be a fair element in the comparison—the advantage of the concrete arch appears far greater. A real money value also attaches to the superior beauty and attractiveness of a decorative arch structure in almost any locality—a question that almost always is the subject of consideration and decision in designing public work, for it must be determined what amount is proper to be expended for mere appearance.

The composite bridges—steel structural frame with concrete envelope—share with the arches, or at least promise to, the quality of permanence, and therefore exemption from expensive maintenance charges. As between the ordinary steel plate-girder bridge with buckled plate floor for permanent paving, and the composite type, the lower first cost is with the composite if the spans be short, for the greater dead weight of the concrete floor tells on the long main girders whose section is usually determined by the general load, dead plus distributed live, while the individual floor members are determined by the heavy concentrated live load. The embedment of the floor stringers or joists in the concrete jack-arch construction effects a saving of steel, first by dispensing with floor plates, and second by permitting lighter stringers to be used, for the jack arches distribute a concentrated load over say three beams where with a buckled plate floor each beam must carry the whole concentration, and besides, the embedment of a beam in concrete increases its carrying capacity about one third.

Where it is the practice to protect steel bridges over railroad locomotive service by means of a wooden ceiling under the whole underside of the bridge the economy of the concrete floor is more marked because such a ceiling costs about 25 cts. per sq. ft. and lasts only a few years. This first cost alone will pay for about one cubic foot of concrete in the floor, and only about 15 to 18 ins. average thickness of floor concrete is required. As steel floor plates with their riveting cost from 50 to 70 cts. per sq. ft., the concrete floor appears to cost only one-half as much as an all steel floor, besides saving materially in the stringers. Floor beams may or may not be required to be heavier to carry the concrete floor. If they are not very long, the value of the concrete embedment may make up for the increased dead load stress. The main girders will need to be heavier than for the steel floor because little or no value can safely be assumed to be derived from the concrete casing.

REINFORCED-CONCRETE CONSTRUCTION—In the field of reinforced-concrete construction three papers were presented. The first, "Advantages of Reinforced-Concrete for Railroad Construction," by Mr. B. H. Davis, Assistant Engineer, Delaware, Lackawanna & Western R. R., was an illustrated descriptive resumé of all the various kinds of applications of the material to railway work. The recommendation of cheap maintenance alone, in Mr. Davis' opinion, makes reinforced concrete one of the most desirable materials for so permanent a structure as the railway must be. Not only is the maintenance cheaper, but the first cost, with the rapidly improving methods of construction, is in many cases as low as for any other material. The views shown included many bridges, viaducts, railway stations, signal towers, tunnels, track works, docks and piers, which have been built and most of which have been described in the technical press.

Mr. Charles M. Mills, of the Philadelphia Rapid Transit Co., read a paper on the "Applicability and Comparative Cost of Concrete and Reinforced Concrete for Subway Construction," which we hope to reproduce in an early issue.

Mr. A. Lindau, St. Louis, Mo., read a paper on the "Value of Cost of Reinforced Concrete for Retaining Walls," in which he defended the L- and T-shaped walls, reinforced with steel, as against the gravity section plain concrete walls. The great objection to the skeleton wall by its opponents is that it has not sufficient weight for stability so that under heavy pressure it will slide. Mr. Lindau stated that this could be remedied by building the bottom of sufficient length to increase the friction on the bottom bearing surface above the safe limit on the soil. In a comparative design of various kinds of skeleton walls and one gravity wall, it was found that, giving to the concrete in the reinforced wall an extra unit charge for concrete on account of the difficulty in laying, the skeleton wall saved 25% in a 10-ft. wall and 35% in a 25-ft. wall. In the address Mr. Lindau showed numerous views of large reinforced-concrete walls.

In a paper on "Necessity and Cost of Cement Inspection," Mr. W. Purves Taylor, Philadelphia, Pa., pleaded for the more general inspection of cement on small jobs. The very fact that inspection is likely to be omitted on such work will cause unscrupulous dealers to attempt to foist bad cement on the contractor. If the cost of regular laboratory experiments are too much, limited and short time tests will be of great value in detecting the lower grades of material. Where a good testing plant can be set up on a job the cost of testing will run from 1 to 2 cts. per bbl., and in the less extensive plants, 4 to 5 cts. Even one-day tests on the job are better than seven-day tests at the mill on account of the liability to change of the cement in transit.

The paper by Mr. F. S. Phipps, St. Joseph, on "Steam Curing of Cement Blocks" and the one by Mr. J. P. H. Perry, New York, on "Cold Storage Warehouses of Reinforced-Concrete Construction" will appear in the near future. Other papers of a purely descriptive nature were read; lack of space prevents us reproducing them.

INSURANCE.—A committee presented a preliminary report of considerable value, although the matter contained therein is only a small portion of what it is expected will be available by the next meeting. About 150 letters were received from owners of various kinds of concrete structures in all parts of the United States, and from these letters and from insurance reports a table of insurance rates has been compiled in a table which, on account of its present incomplete state, will not be presented here. The report says:

It is fully realized that so many conditions affect rates of insurance that it would be impossible to set an accurate average rate for each type of building, for the reason that rates of insurance on buildings are generally dependent; first, on the height and area of the building; second, on the surroundings; third, on the character of protection of exposed openings; fourth, on the facilities for fighting a fire, and fifth, on the contents.

The annual report of the National Board of Fire Underwriters for the year 1907 shows that the average rate of insurance for the year on all classes of buildings amounts to $1.15 per $100. The average rate on the concrete buildings is less than four-tenths of one per cent. All except two buildings have rates less than the average rate given by the Fire Underwriters for all classes of buildings for the year 1907. Of these rates one was for a building in San Francisco, a city which is composed largely of frame structures, while the other is for a frame building partly replaced by reinforced concrete having a $4.00 rate on the frame portion. Attention is also directed to the fact that some owners find it inexpedient to carry insurance of any kind. One company in particular, who could only obtain a very excessive rate of insurance on the contents of their building, found it desirable to carry their own insurance since the annual premiums they would have to pay on the contents, capitalized, would in time afford them protection from possible fire; they did not deem it necessary to insure the building itself. Many of the rates on buildings quoted are unnecessarily high, the rates being influenced by the character of the surroundings. For example, one of the rates cited was for a building in which a reinforced-concrete structure had replaced a portion of a frame building, which carried an original rate of $4.00. By reason of this frame building adjoining the reinforced-concrete structure without a fire-wall between, the rate on which remained the same—namely $4.00—the insurance company would only issue a rate of $1.25, whereas if the entire structure had been of reinforced concrete, the rate would have been considerably under $1.00.

SPECIFICATIONS AND REGULATIONS.—A large part of the time of the convention was taken up in the discussion of specifications and building regulations which are to be submitted to letter ballot before being issued as official standards of this Association. In this connection a new by-law was passed by which any such specification or regulation passed to letter ballot will become official unless rejected by 10% of the total membership. This method of voting on the letter ballot is novel to this Association, or, so far as we know, to any of the national societies.

The first specification submitted was a new one on "Sidewalks." At the last annual convention a specification on this subject was ordered to letter ballot and accepted by that means later in the year. However, certain changes were thought necessary, and, after a long and tedious discussion a new specification was adopted, not differing materially from the one adopted last year except in minor detail and arrangement, except that the method of making expansion joints was left open. As the specification does not become official until passed by letter ballot, we omit publishing it until such time as it is so passed. A somewhat similar specification on concrete roads was submitted, but owing to the general lack of knowledge concerning such construction among the members of the Association the specification was passed over until next year.

Upon the "Suggested Standard Building Regulations for the Use of Reinforced Concrete," one of the longest and most involved meetings of the convention was held. This meeting started about 10 o'clock in the morning and, with an interval for lunch, continued through till 7 p. m. This regulation, it is hoped, will be used by various municipalities as a basis for building laws on concrete construction. The suggested form, which was adopted with many changes, was submitted by a committee, some of whom are members of the Joint Committee on Reinforced Concrete of the American Society of Civil Engineers, the American Society for Testing Materials and the American Railway Engineering and Maintenance of Way Association. This Joint Committee after four year's deliberations have at last prepared a report which will be presented to each of the above societies, first at the annual meeting of the American Society of Civil Engineers this month. Upon this joint report the suggested regulations of the cement users was founded. The regulations are the first authorized and official standards upon which any city can form its laws and as such should do a great deal of good in the campaign for uniform building regulations. Until the corrected regulations are officially confirmed we will not publish them.

Officers.

Practically the same officers continued in office for the ensuing year. The principal offices are held as follows: Mr. Richard L. Humphrey, President; Mr. Merrill Watson, First Vice-President, and Mr. George C. Wright, Secretary. The offices of the Association are in the Harrison Bldg., Philadelphia, Pa., to which place all inquiries regarding the society should be sent.

The Association is on a remarkably stable financial basis, due in a large part to a number of contributing members paying extra annual dues. Out of surplus of some $2,000, about $700 came from these members. No place for the holding of next year's convention will be decided upon until later in the year, although Atlanta, Ga.; Atlantic City, N. J.; Columbus, O., and Cincinnati, O., presented their claims for consideration.

CARBON MONOXIDE IN ILLUMINATING GAS in the District of Columbia is to be restricted to 10% of the total volume. The Commissioners of the District have recommended to Congress a bill providing that this restriction be made and that examinations of the gas be made at regular intervals by the inspector of gas and meters. Accidents ascribed to carbon monoxide given off by gas heaters in Washington, D. C., were noted in Eng. News, Vol. 60, pp. 531 and 755, and the results of tests of such a heater for production of carbon monoxide were recorded on p. 687 of the same volume.

Annual Report of the New York St[ate] Public Service Commission for the Firs[t] District (New York City).

Less than two years ago New York S[tate] placed all public service companies under c[ertain] supervision by instituting Public Service C[ommissions] having very large powers. There a[re] two of these commissions, one for New York C[ity] (Commission for the First District) and th[e] other for the rest of the state (Commission for t[he] Second District). The former,* having to dea[l] with the complex problems of railways, street[-] lines, rapid-transit railways, and gas and ele[c]tric companies in New York City, is also su[c]cessor to the old Rapid Transit Board (which [b]uilt the rapid-transit subway), and therefore [h]as the duty of planning new rapid-transit rout[es] recommending franchises therefor, building [m]unicipal lines, etc.

The present report of this commissi[on] to the state legislature is the first coverin[g] a full year's work. It is of general interest to engineers, not only because of the particular problems dealt with or actions taken, but also because it bears directly on the question whether it is feasible to secure to the public satisfactory public service with private ownership, by authoritative and detailed control through a special public body. In this light several passages of the report are suggestive, for example the commission's refusal to give its aid to an attempt at setting up competition in electric service, its orders to the existing electric monopoly to make fair contracts, its work for ameliorating conditions in the subway and on surface cars, etc. It is more necessary to get a full understanding of the importance of the commission's work for the reason that it is rather expensive. Excluding the salaries of the commissioners, the counsel and the secretary, all paid by the state, the cost of the commission falls on the city. For 1908 it amounted to $1,000,000. For 1909 it is estimated to be $987,500. But the greater part of these amounts, about 60%, is spent for making plans of new rapid-transit lines and directing their construction. Thus the cost of the real public-service supervision in the city is only about $400,000 per year.

The report comprises a general summary, appended detail reports of its work, and full statistics. We reprint the general summary here, with minor omissions:

Report for Year Ending Dec. 31, 1908.

The Commission has jurisdiction in the counties of New York, Kings, Queens and Richmond over railroads and street railroads and gas and electric companies; and under the Rapid Transit Act, jurisdiction as to the laying out of rapid transit routes, the preparation and supervision of contracts for construction and operation of such routes, and, in certain cases, the granting of franchises.

The surface, elevated and subway companies in New York City carry annually over 1,300,000,000 passengers, which is over 66% more than the total number of passengers carried on the steam railroads of the entire country. These companies have a capitalization of over $533,000,000, and derive annually from their passengers over $62,000,000. The gas and electric companies have a capitalization of over $386,000,000, and the amount of gas sold annually is over 32,000,000,000 cu. ft., which is more than 20% of the entire gas production in the United States. The income from the sale of electricity in the city is over $20,000,000.

Rapid Transit Subway, Elevated and Tunnel Lines.

Over $50,000,000 has already been expended by the city to build subways. The Fourth Avenue subway, the Broadway-Lexington Avenue system, the Loop lines and the Canal Street extension, additional lines planned by the Commission, will involve additional expenditure of over $100,000,000. These rapid transit plans or routes, in addition to any extensions planned by the existing companies, are considered imperative by the Commission. Even these will not fully relieve the congestion that now exists, not to mention the future increase in traffic.

The original subway, including the Van Cortlandt Park

*It consists of Wm. R. Willcox, Ch.; Wm. McCarroll, E. M. Bassett, M. R. Maltbie, and J. E. Eustis. Mr. Travis R. Whitney is Secretary and Mr. Henry B. Seaman is Chief Engineer.

extension and the so-called Brooklyn subway, is now in operation in its entirety. The various sections of the Brooklyn subway were put into operation as they were completed. The portion from City Hall, Manhattan, to South Ferry, was opened on July 10, 1905. The tunnel under the East River, from Bowling Green to Borough Hall, was opened on Jan. 9, 1908. The remaining portion, to the Atlantic Ave. station of the Long Island Railroad, was opened on May 1, 1908. The Interborough Rapid Transit Co. operates these two subways as a transportation unit, carrying passengers from Atlantic Ave. to the Bronx termini of the road for a 5-ct. fare.

IMPROVEMENT OF THE SUBWAY OPERATION.—The Commission has, during the year, received a number of reports submitted by Bion J. Arnold, who was retained as special engineer to make an investigation and to report upon the subway as operated. As the result of his recommendations the Commission has directed the Interborough company to equip two experimental trains with side doors, to the end that if found successful the company will be ordered to equip all of its subway cars with side doors. Mr. Arnold has made other important recommendations as to improvements in the construction and operation of the subway, which are now being considered. The purpose of the Commission has been to utilize every possible method known to engineers to increase the carrying capacity of the subway and relieve congestion.

Following the recommendations of Mr. Arnold, the Interborough company was requested to install a new type of signal system on the express tracks, which, by a method of speed control, would allow express trains to approach stations by shorter blocks than had formerly been the practice. By this means, when a train is at the station the next train is held just outside of the station instead of in the next block; less time is therefore lost in the arrival of trains at the stations during rush hours and a larger number of trains can be operated. This system has been put into use at the 96th St. station and is working so satisfactorily that the company is about to install it at other stations.

The Commission has directed the Interborough company to make certain changes at Bowling Green station to cost about $90,000 which, by allowing a shuttle service between Bowling Green and South Ferry stations, will permit the running of all of the express trains to Brooklyn. Heretofore a certain proportion of such trains had to go around the loop at South Ferry, although the Brooklyn travel was very urgent at certain hours. This will increase considerably the usefulness of the subway to residents of Staten Island.

The Rapid Transit Commission had ordered plans to be prepared for the improvement of the 96th St. station. Some improvement was considered necessary because the arrangement of the tracks at this station rendered it impossible to operate as many trains through this station as could be operated upon other portions of the route. Certain improvements were made by this Commission in the plans outlined by the Rapid Transit Commission and were submitted to the Board of Estimate and Apportionment for their approval. The expenditure of the money having been authorized, work was begun toward the close of the year. It is claimed by the engineers of the Interborough company that these plans or others equally as good will increase the capacity of the subway from 20 to 30%.

FOURTH AVENUE SUBWAY.—In its first report, the Commission stated that it had determined to proceed with the Fourth Ave. subway as planned by the Rapid Transit Commission. The Commission took this action after it had ascertained that the Board of Estimate and Apportionment had officially advised the Rapid Transit Commission to undertake the route and after various members of the Board of Estimate and Apportionment had asserted that the city was pledged to its construction. In order to increase the efficiency of the lines, to give it greater usefulness, to enable large standard cars to be used and to decrease the cost of operation, the Commission changed the plans so as to increase the height of the subway and to cut all grades in the subway down to 3% or less. The Commission then approved the detail plans and prepared forms of contracts which were approved by the Board of Estimate and Apportionment. Due legal advertisement for bidders was made and on May 8, 1908, bids were opened. Thirty-six bids were received and after consideration, the Commission accepted bids and thereafter on May 26, 1908, transmitted a communication to the Board of Estimate and Apportionment of the city advising it of the steps that had been taken in conformity with the previous action of the Board toward securing bidders and recommending that the contracts, as awarded by the Commission, be approved, and that an appropriation of a little over two million dollars be made in order that immediate construction might be begun. The Board of Estimate at the meeting at which it was to take action, was served with papers in an injunction suit obtained on the representation that the city was so near its constitutional debt limit that the necessary appropriation could not properly be made. Certain questions that arose in this proceeding were sent to a referee who is still taking testimony. This proceeding is still undetermined, and the Commission can not proceed until the Board of Estimate approves the contracts or part of them.

BROOKLYN UNION ELEVATED, FLATBUSH AVE. APPLICATION.—The Brooklyn Union Elevated Railroad Co. made application under date of April 20, 1908, for a franchise to build and operate a four-track elevated railroad in Flatbush Ave. in the so-called Flatbush Ave. extension from Fulton St. to the Manhattan Bridge and for the exclusive right to operate over two of the tracks of the Manhattan Bridge. The Commission gave full consideration to this application and concluded that it was inadvisable to grant the franchise largely because the company contemplated operation to and across the Manhattan Bridge to the Manhattan terminal of the bridge only. This contemplated repetition of the condition that has existed at the Manhattan terminal of the Brooklyn Bridge, with the additional factor that the Manhattan Bridge terminus is not even a focal distribution point for passengers, was considered very objectionable by the Commission. Furthermore, the Commission did not deem it advisable to grant exclusive rights to use any portion of the bridge structure for a long period of years.

It further was of the opinion that the connection between the Fulton St. and Myrtle Ave. elevated lines of the Brooklyn Union system on the Manhattan Bridge could be made through other streets than the Flatbush Ave. extension, which has been so laid out that it is an essential part of an important thoroughfare extending from the North River across Manhattan and through Brooklyn to the Atlantic Ocean. Provision had already been made by the Commission for a four-track subway through the Flatbush Ave. extension, this being a part of the Fourth Ave. system. This route, extending from the Atlantic Ave. station of the Long Island R. R. down Fulton St., through the Flatbush Ave. extension, over Manhattan Bridge, through Canal St. and Centre St. to City Hall, Manhattan, provides excellent transportation facilities for this section of Brooklyn, not only to the Manhattan terminus of the Manhattan Bridge but into the heart of Manhattan. It also provides a more effective and desirable method of utilizing the Manhattan Bridge than the proposal of the Brooklyn Union Elevated Railroad Co.

BROADWAY-LEXINGTON AVE.—The Commission in December, 1907, adopted the Broadway-Lexington Ave. route. This route runs from the Battery, through Greenwich and Vesey Sts. and Broadway to Ninth St., thence under private property and streets to Irving Place, thence up Irving Place and Lexington Ave. to the Harlem River, then to 138th St., where it divides into two branches, one going north through Mott, River and Jerome Aves.; the other northeast through 138th St., Southern Boulevard and Westchester Ave. to Pelham Bay Park. A diligent canvass was then made of the property owners along the new portion of the route, but the efforts to secure the consents of the owners representing one-half of the value of the property along the line, were unsuccessful and the Commission then applied to the Appellate Division for its consent in lieu of the consent of property owners. The Commissioners who were appointed were compelled to extend their sittings over a considerable period of time because of certain opposition which manifested itself, but finally, on Nov. 16, 1908, they submitted their report approving the route to the Appellate Division. The court rendered a decision approving the report on Dec. 24, 1908.

The Engineering Department of the Commission had in the meantime made considerable progress in the preparation of the studies for the detail plans and it is expected that in a short time, the Commission will be able to adopt the detail plans submitted by its Chief Engineer.

CANAL ST. EXTENSION.—The Canal St. line, also approved in December, 1907, is an extension from the Manhattan end of the Manhattan Bridge through Canal St. to the North River, with possible physical connection at the Broadway point of intersection. The route as thus adopted was duly submitted to the Board of Estimate, which on March 13, 1908, gave its approval. Detail plans are now being prepared.

BROOKLYN LOOP LINES.—The Commission has pushed the construction work on the so-called loop subway through Centre, Canal and Delancey Sts. as rapidly as possible, giving due consideration to the difficulties that have been encountered. In spite of the best efforts of the Commission, the completion of this subway will be delayed considerably beyond the time anticipated, largely due to complete stoppage of work in Section 9-0-1. This was rendered necessary by a request from Mayor McClellan that work be suspended pending the completion of plans for the municipal building. The city has under consideration the construction of a large office building on the plot bounded by Park Row, Duane and Centre Sts., where there will also be located one of the subway stations. Because of the nature of the soil, it was deemed necessary that the foundations extend below the subway, and the Mayor, therefore, requested that the subway work be suspended until the foundations could be placed.

BROADWAY, BROOKLYN.—The Commission has directed its Engineering Department to prepare plans for the construction of a subway extending through Broadway, Brooklyn, from the Brooklyn terminus of the Williamsburg Bridge. These plans will be completed as soon as those of the Broadway-Lexington Ave. system and the Canal St. line are completed.

STEINWAY TUNNEL.—On Feb. 27, 1908, the Commission received a communication from the Interborough Rapid Transit Co. suggesting that the Commission approve of the purchase, on behalf of the city, of the tunnel under the East River at 42d St., known as the Steinway tunnel, constructed by the former New York & Long Island Railroad Co. The Commission took no action on this application because it was of the opinion that it had no legal authority to consider such a proposition. Under an amendment to the Rapid Transit Act, however, passed at the last session of the Legislature the company on May 26, 1908, renewed the proposition.

The company proposed that the Commission authorize the purchase of the tunnel at the cost of construction, and then lease it back to one of the companies of the Interborough Rapid Transit system for a period of 25 years, with the right of renewal for twenty-five years, under an arrangement whereby the city should pay one-half of the cost of operation and receive all of the fares from passengers riding through the tunnel only, and the company to receive all of the fares of passengers riding through the tunnel and on the surface lines in Queens County.

The Commission caused its Bureau of Statistics and Accounts to make careful examination of the cost of construction and its Chief Engineer to examine and report upon its physical condition and possible connections and traffic possibilities. The Commission concluded from the facts developed that it was inadvisable to recommend the acceptance of the offer.

Besides numerous other objections it appeared that such a contract for operation as was suggested by the Interborough company would cost the city some $350,000 a year.

Supervision.

COMPLAINTS AND ORDERS.—The Commission has received during the year upwards of 3,000 complaints from residents of the city of New York, as to the service rendered by transportation companies. The Commission has adopted the practice of handling many of these complaints by informal correspondence with the companies and the complainants. Where the matter complained of has related to the physical condition of the track or equipment inspection has been made, and informal suggestion sent to the company as to improvements. This method of handling such complaints has proved generally satisfactory. In other cases the Commission has made the complaints the basis of formal proceedings, terminating in orders to the companies. A digest of the proceedings before the Commission is given elsewhere, as well as the orders of the Commission, publication of which is required by the provisions of the law.

The Commission has also received about 9,000 complaints affecting gas corporations and electrical corporations, chiefly as to the accuracy of meters. Nearly all of these cases have been adjusted, without any formal hearing, to the satisfaction of the complainant. In a few instances it has been necessary to hold an informal hearing before one of the Commissioners to arrive at a determination of the facts. In none of these cases has it been necessary to issue an order. The companies have, in every instance, accepted the findings and given the relief suggested.

JOINT FARES ON STREET RAILWAYS.—On Aug. 5, 1908, the receivers of the Metropolitan Street Railway Co. ceased to operate the 50th St. Crosstown line and other lines of the Central Park, North and East River Railroad Co., under the lease from that company. The operation of these lines was then undertaken by the Central Park company. This terminated the transfer privileges at the intersection of the 50th St. line and the north and south lines of the Metropolitan system. Because this required the payment of three 5-ct. fares to travel in a generally diagonal direction in the territory between 34th and 116th Sts., in Manhattan, the Commission, following the receipt of numerous complaints, ordered the receivers and the Central Park company to establish through routes and joint rates. This they failed to do, and the Commission then began the taking of testimony to determine the proper joint fare and its division between the two companies. The companies were also given opportunity to present evidence and to make argument. After careful consideration the Commission ordered the establishment of a 5-ct. joint fare on the lines of the two companies in the territory between 34th and 116th Sts., to be divided 3¾ cts. to the Metropolitan company and 1¼ cts. to the Central Park company. Thereafter the companies obtained writs of certiorari to review the action of the Commission. Counsel to the Commission then made a motion in the Appellate Division, First Department, to quash the

writs, which was denied. Consent was given to an appeal to the Court of Appeals.

The Commission also began proceedings to secure a joint fare between the lines of the Third Ave. system and of the Central Park company, which, at the end of the year, are undetermined.

STOCK AND BOND APPLICATIONS.—The act provides that stocks or bonds or other certificates of indebtedness may not be issued for periods longer than twelve months without the approval of the Commission, and then for four purposes only, viz.: 1. Acquisition of property; 2. Construction, completion, extension or improvement of facilities; 3. Improvement or maintenance of service; 4. Discharge or lawful refund of obligations.

During the year several important applications have been made to the Commission for the approval of issues of stocks and bonds. In the case of the Long Acre Electric Light & Power Co., a company long dormant, which proposed to enter into competition in the electric field, the Commission disapproved of the proposed issue of $10,000,000 of stock and $50,000,000 of bonds on a number of grounds, among them that as to a public service which is in a measure a natural monopoly, and *where an existing company has the capacity and is rendering efficient service, with power in the Commission to compel a maintenance and improvement in the standard, it is economically unsound to allow a duplication of plant* with the possibility of increased burden to the public through possible future common control.

Ten applications have been made, requesting approval to a total issue of $13,010,000 stock, $92,204,000 bonds, and $50,000,000 of notes or other evidence of indebtedness. Favorable action has been taken by the Commission and approval granted of $3,000,000 stock, $41,742,000 bonds, and $25,000,000 of notes. In all of these applications the Commission has been careful to ascertain that there was sufficient property upon which to base the securities, and that the proceeds arising from the issues may be used only for the purposes allowed by the law. To insure this the Commission has required that periodical statements be filed, showing the application of proceeds, and it has also the power to examine the vouchers and records of the companies.

EQUIPMENT.—Under its power to require changes in equipment and appliances the Commission has ordered the complete and thorough overhauling of all of the surface cars operated in the boroughs of Manhattan and The Bronx. As a result the noise and strain incident to the running of rattling cars with flat wheels has been enormously decreased, car efficiency has been increased, the appearance has been improved, the cost of operation decreased and the safety of the public better protected.

The cars of the Metropolitan system proper, which were in such wretched condition that over 20% were unable to complete a day's service without being "run in" for temporary repairs, have been overhauled under specifications prescribed by the Commission, so that now the daily "run ins" for repairs have dropped to 5%. The receiver of the Third Ave. system has testified that he "expected to find a going concern, but found it nearly gone." He has, however, bought additional equipment, repaired and relaid tracks, and is furnishing such service as to have reduced very materially the complaints against this road.

Because of complaints and because of lack of proper efficiency in the service the Commission has had careful investigation made of the equipment in use throughout the district, and has found it necessary to order practically all of the cars either to be completely overhauled or to be improved in certain specified particulars. As just stated, the cars on the surface lines in Manhattan and the Bronx and the Coney Island and Brooklyn Railroad Co. were in such bad operating and sanitary condition that their complete overhauling was necessary.

FENDERS.—The enormous number of accidents, reaching nearly 50,000 in a year and including nearly 600 persons killed, called striking attention to the lack of safety devices, and the Commission has conducted extensive and satisfactory tests of fenders and wheel guards, open to all manufacturers in this country and abroad, to determine what ought to be done to save life. This work was completed just before the end of the year.

The Commission will now, following proper notices to the companies and after hearings, require the installation on the cars of fenders and wheel guards that have met the tests of the Commission satisfactorily.

Another matter to be taken up immediately will be the proper types of brakes. Already the Brooklyn Union Elevated Railroad Co. has been directed to install a more efficient brake than that now in use on its elevated cars.

Use of proper safety devices and brakes will, it is anticipated, decrease very largely the number of serious accidents. The next largest class of accidents arises from the fault of employees of the roads, such as overspeeding and apparent lack of proper instruction. This cause is perhaps more difficult to eliminate because of the human element involved, but its importance is unquestioned.

The Commission found in its examination of equipment, particularly new equipment about to be purchased by the companies, that it was advisable, and ordered, that the companies should file specifications in advance of purchases. By this means it has been possible to point out important defects before equipment was completed, and at a time when their elimination was less expensive to the companies than after the cars were put in use. As a matter of legal authority the Commission probably does not have the power to compel a company to make any change in its equipment until the equipment is put in public use. In European countries the possession of this power by the boards exercising state supervision over public services requires the approval of general plans of equipment before being purchased and has been very satisfactory.

INCREASE IN SERVICE.—The Commission may require by order increases in service under the provisions of the act that companies shall furnish adequate service and shall have sufficient cars and motive power to meet any requirements of transportation that may be reasonably anticipated. The problem presented, however, of defining what will be regarded as adequate service is shown by the fact that in the year 1907, disregarding the number of transfers, there were carried on the roads of New York City 66,000,000 more fare passengers than in the year 1906. As an average, this means that there were 180,000 more passengers each day during the year than on the day before.

The problem of what will be deemed adequate service on street car lines in a great city is purely relative. It differs from that presented in the case of lighting companies, for, with gas and electric companies, there is a well understood unit of service and a unit price. In transportation there is no unit of service other than that a passenger upon a payment of a fare is entitled to a ride. What does this mean where 20% of the total travel takes place in a single hour? There are limits to the number of tracks on a leading street and to the number of cars that can run over the tracks in an hour.

The Commission has endeavored to increase the efficiency of service by requiring improvements in equipment. It has studied street congestion and attempted to have routes so changed as to avoid the limiting points of capacity. It has also insisted that the rush-hour service shall begin earlier and be continued later than has been customary. There *is* a period in New York City during which it is physically impossible to furnish seats for all, but the companies had fallen into the practice of limiting the maximum service they provide to a short time in the height of the rush-hour period, thus providing inadequate service, when they could have operated more cars. *Companies recognize that standing passengers are very profitable, and there is a constant struggle to prevent the companies from causing unnecessary inconvenience to their passengers during non-rush hours.*

The Commission has decided that transportation companies should run as many cars as it is physically possible to operate during rush-hours, that the number of seats should equal if not exceed the number of passengers in a short period of time, and that the only excuse for not providing such service shall be insuperable physical conditions or events which it is impossible to foresee. This standard of what adequate service is has already been applied by orders of the Commission to several lines, and investigations are now being made preparatory to its application to other lines, surface, subway and elevated.

GAS AND ELECTRIC COMPANIES.—With gas and electric companies, the problems which have arisen during the past year have related principally to the instruments for measuring the service furnished and to the conditions that the companies have sought to impose in their "contracts" for service. The question of the price of gas had been under litigation in the United States courts for two years and the Supreme Court has just decided the law constitutional. The Commission is now free to take up the many matters as to gas companies demanding attention. No gas meters may be placed in use until tested by the Commission and the Commission has recently required that all meters that have been in use for more than seven years shall be removed and retested. The various types of electric meters in use in the city are being tested and examined to determine whether there are any that ought not to be used because of defects in principle or nature of construction.

As to contract conditions sought to be imposed by electric companies upon consumers, the Commission has given them careful attention and after a protracted inquiry has issued an order that requires the companies to file 30 days in advance of their effectiveness all forms of contracts, schedules of rates, etc. This, with an order prohibiting discrimination among customers, should result in the elimination of complaints that the electric companies are giving special rates to favored or large customers. One of the conditions imposed by the companies when the electric inquiry was beg... that a consumer could take electricity fro... source even including in the prohibition hi... ing plant. This condition was gradually dr... use the private plants in the large buildi... owners could not run the risk of their ... breaking down and be without the ability ... tricity from the company. The Commission ... about an agreement upon the part of the co... give "break-down" and "auxiliary" service ... of private plants.*

... provided ... other ... light- ... out of ... for the ... plants ... elec- ... brought ... ies to ... owners

Rapid Transit Extension at a Sta... ill; Remedies for this Condition.

In the second chapter of its report ... Commission discusses the serious situation ... gard to the question of rapid-transit facilitie... New York City. The subway, opened in 1... was very soon taxed to its full capacity. T... need for additional subway lines has become ... ident in most convincing manner. The B... d of Rapid Transit Commissioners, after ... lying the matter, laid out a comprehensive s... m of new lines, but only one, a short loop ... connecting the lower East River bridges ... the Manhattan side (Centre Street loop) h... been put under construction.

Two causes have prevented further rapid-transit construction: (1) The fact that New York City has practically reached its constitutional limit of bonded indebtedness (10% of assessed valuation), so that no money is available for building city-owned lines. On this ground the letting of contracts for the Fourth Avenue subway, in Brooklyn, has been held up. (2) The laws governing rapid-transit construction were amended in 1906 by imposing more rigid conditions on future contracts and franchises, and one result hereof was the discouragement of private construction. The net result is that at present there is no prospect for more rapid-transit lines, at least in many years to come, unless legislative action modifies the present limitations. The Commission makes some pregnant suggestions in this direction.

Referring to the law under which the existing subway was built, and why this law was later changed, the Commission says:

It (the old law) provided one method, but only one method of building a subway. The contractor should build it for a sum agreed upon, the city furnishing the money and owning the subway. The same contractor should then equip it at his own expense and have the exclusive operating rights therein for a long term of years, paying for this privilege the interest on the money borrowed to build the subway and in addition an annual amount which would amortize such indebtedness in fifty years. The good features of this plan were that the capital cost from 3 to 4%, instead of nearly 6%; that the contractor being also the long time operator would be under an inducement to do good work; that the contractor being under obligation to pay interest and sinking fund on the entire cost had a motive for economical construction; and that the contractor, being also the operator, was under an inducement to construct rapidly so that the earning might begin. The term of operation was made fifty years, with provision for a renewal of twenty-five years. * * *

The subway operators capitalized their property so that there appeared to be a huge immediate profit. This was followed by an exhibition of a desire on the part of the owners of the surface railroads of Manhattan to obtain competitive subway rights. For two years the impression rapidly gained ground that New York city had a gold mine in the unused subsurface of its streets and that steps should be taken to render their seizure as difficult as possible. In partial response to this demand that at that time seemed so well justified, the Elsberg amendments of 1906 were passed by the Legislature. The amendments as introduced in the legislative session of that year looked mainly to a separation of the contracts for construction, equipment and operation, but a popular demand arose that insisted on a radical reduction of the operating term. * * *

The changes made possible separate contracts for construction, equipment and operation. The longest term of operation was made 20 years with a possible 20 years' renewal. The ability to make extensions of existing rapid-transit lines was carefully guarded. If an elevated railroad company wanted to third-track or extend its road it could obtain rights for 25 years, with a possible renewal of 20 years more, all structures so erected to become the property of the city without payment at the end of the grant. The operators of the present subway could make extensions in two ways, one by obtaining city construction, upon the cost of which the com-

*Engineering News, July 30, 1908, p. 123.

pany would be required to pay interest and sinking fund, with operating rights for 20 years and a possible 20 years' renewal. The company could build an extension with its own money, taking a franchise for 25 years with a possible 25 years' renewal, and surrendering the subway extension and its fixed equipment to the city without payment at the end of the grant.

THE PRESENT PROBLEM.—The main argument for private construction and operation of rapid-transit lines is that the rapid development of the city renders necessary more construction than can be accomplished with city money. * * * If with a full knowledge of the results the law-making power decides that the best development of the city demands the continuation of the present method of construction with city money only, the future although perhaps more full of difficulties is not without prospects of progress. The following considerations will then become imperative: (1) The debt incurring ability of the city must be increased. (2) The severity of the operating contract requirements must be lessened. * * * Terminal extensions are where they earn least, yet the present law imposes the most severe burdens upon them. It would seem right that the Rapid-Transit Act should be altered so that surrender without compensation shall not be required in such cases. Then, too, the provisions under which the present operators of the subway can make extensions beyond present termini are unduly onerous and should be modified. The same remarks apply to the requirements regarding three and four tracking of existing elevated railroads.

The present law is not adapted to the needs of the Manhattan portion of the Brooklyn loop lines now in course of construction. This subway extends from the Brooklyn Bridge through Centre St. and Delancey St. to the Williamsburg Bridge with a spur through Canal St. to the Manhattan Bridge. Contracts for construction alone were let by the Board of Rapid Transit Commissioners. While it is possible that this subway may in the future be operated by a single contractor it is not likely. * * * The Rapid-Transit Act refers to a single operator for each subway and provides that this contractor shall pay interest on cost and also an annual sum for sinking fund. If no operating contract can be made excepting on these terms it may limit the use of the subway to operation by the city only, because the first operator might not be able and probably would not be willing to pay the interest and sinking fund on the cost of the entire subway when using only a part.

There seems to be no way of operating such trunk subways except to abrogate the requirement that the payments by the operator must equal interest and annual payment for sinking fund on the entire cost or else have the city operate the whole. It is obvious that any such change may permit trunk subways to occupy much the same position as bridges and highways, and the tendency may be to fall short of self-support.

The inelastic requirement of the present law, that no contract for operation can be made that provides for a smaller annual payment to the city than interest and a sum that will amortize the entire cost in 50 years, and that otherwise the city must itself operate, stands in the way of the proposed development of rapid-transit routes. In some cases it might compel municipal operation regardless of its desirability in the specific case. In others it precludes the possibility of obtaining an operator for a period at the beginning. Greater freedom should be given to those who have to arrange the terms of operating contracts, and so long as the concurrent action of the Board of Estimate and Apportionment and a State board like the Public Service Commission is requisite, there is little danger that the terms will be made more lenient than the situation actually demands. These two authorities should be allowed to make the best possible terms with a private company for operation and also to undertake municipal operation if no private operator can be secured upon reasonable terms, or if municipal operation seems preferable. The principle of acquiring interest and provision for a sinking fund would ordinarily be observed, but the city ought not to be bound to take an operator upon certain terms specified in advance or *else be compelled* to adopt municipal operation.

LOCAL ASSESSMENT FOR DEVELOPMENT OF LINES.—It seems inevitable that in the creation of a comprehensive rapid-transit system some portions at least in the beginning must be supported to some extent by the general city revenue. Some parts of such a system will perform a function similar to that of bridges which are of such general benefit that the cost is fairly levied upon the entire city. But this principle does not apply to rapid-transit lines constructed at the city's expense in far outlying localities, where the benefit for the entire city is remote and the immediate benefit is almost entirely to the undeveloped land within half a mile on either side of the rapid-transit line. The Commission has considered the subject of a plan for assessing all or part of the original cost of a development subway upon the real estate benefited. It believes that further study should be had to perfect a plan and express it in permissive legislation so that in proper cases this method may be used to obtain money for construction. It has been pointed out repeatedly that the increase in real estate values in the upper west side in Washington Heights and in the Bronx, due to the building of the subway, alone was several times the cost of the entire subway.

If a fair law can be framed for assessing the cost of development subways, in whole or in part, on the real estate benefited, and if the Rapid-Transit Act could be amended so that operating contracts of city owned subways in proper cases could be made on less stringent terms than now, there would be three methods of obtaining city owned rapid-transit lines:

(1) Routes connecting business and transportation centers where there is travel all day in both directions should be contracted for as was the present subway; i. e., one contractor for construction, equipment and operation, with provision for annual interest and sinking fund. Such a rapid transit line would be self-sustaining from the beginning, and in case the concurrent resolution, exempting self-sustaining rapid-transit and dock bonds from the constitutional debt limit, is passed by the Legislature of 1909, and approved by the voters next fall, it would not decrease the borrowing ability of the city. The best of such routes can be made to support non-remunerative, but useful extensions.

(2) Routes performing a function analogous to bridges or adapted to the use of more than a single operator, or where for any reason it is not practicable to make a definite operating contract in advance, should be built under a contract for construction only. Although such rapid-transit lines might be a charge against the general revenues of the city in the beginning, they should ordinarily be planned to be ultimately self-sustaining.

(3) Development routes should be assessed in whole or in part upon the real estate benefited. The portion of the cost that the city should ultimately assume should be a sum upon which the net earnings would be reasonably certain to pay interest and sinking fund at or soon after the beginning of operation.

The prospective profit of the proposed route, if doubtful, could be ascertained by submitting it to a public letting for construction, equipment and operation. If there were no bidders, it would be apparent that the route should be classed under either the second or third of the above divisions. If it were a line plainly of benefit to the entire city and not for the development of a single limited locality the contract should be made for construction only and its earnings built up after completion as opportunities presented. If, however, it was intended for the development of a locality the contract should be for construction only with a provision for assessment in whole or part.

RECOMMENDATIONS.—We make the following recommendations:

1. A constitutional amendment exempting bonds for the construction of rapid-transit lines from the 10% debt limit, when, so far and so long as such rapid-transit lines shall be self-supporting.

2. An amendment to the Rapid-Transit Act providing that operating contracts for extensions of rapid transit lines may be made to terminate at the same time as the original operating contract, this Commission having the power in conjunction with the Board of Estimate and Apportionment to fix the terms, conditions and compensation and to readjust the same each 20 years thereafter. Such phraseology should be used as will make it clear that extensions proceeding beyond terminals are alone intended.

3. An amendment to the rapid-transit act which shall give this Commission the power in conjunction with the Board of Estimate and Apportionment to allow the construction and operation of rapid-transit lines by private companies upon payment of part of the earnings to the city, or other proper terms and with a reservation to the city to purchase at any time after a certain period not more than 20 years and without any payment for the franchise itself.

4. An amendment to the Rapid-Transit Act which shall give this Commission the power, in conjunction with the Board of Estimate and Apportionment, to grant franchises to existing corporations owning rapid-transit lines, to construct and maintain extensions or to lay and maintain additional tracks on the whole or part of their routes, with a reservation to the city of the privilege to purchase at any time after a certain period of not more than 20 years and without any payment for the franchise itself. Such phraseology should be used as will make it clear that extensions proceeding beyond terminals are alone intended.

5. An amendment to the Rapid-Transit Act making it possible for this Commission, in conjunction with the Board of Estimate and Apportionment, to make operating contracts for a longer period than 20 years or else to make operating contracts terminable at any time after a certain period of not more than 20 years, with a provision that the equipment shall be purchased at a fair price by the city at the termination of the contract.

6. An amendment to the Rapid-Transit Act rescinding the requirement that the operator must pay interest and a specific annual sum for sinking fund on the entire cost of a rapid transit line, and permitting the Commission and the Board of Estimate and Apportionment to adapt the operating contract to the specific needs of each case.

7. The Commission favors permitting the cost of rapid-transit lines to be assessed in whole or part on the lands benefited, but it is not yet prepared to recommend a definite method.

A 1,200-Volt Direct-Current Electric Railway.*

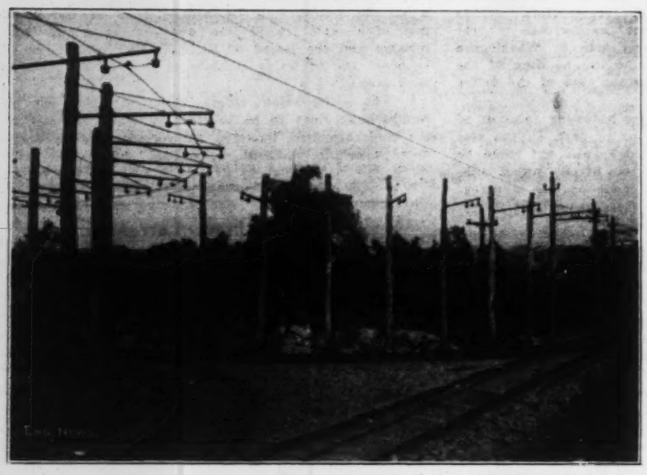
The opening of the Pittsburg, Harmony, Butler & New Castle Ry. gives a new opportunity of observing the operation of an interurban traffic system for which strong claims have been made. The use of direct-current trolley-wire voltages has steadily risen from 500 to 750, but very few installations over 1,000 have been made. It is claimed that this Pittsburg, Harmony, Butler & New Castle Ry. is the pioneer high-tension direct-current road of the country, as the plans were drawn before those of the Indianapolis & Louisville Ry., which is said to be the first to operate under 1,200 volts.

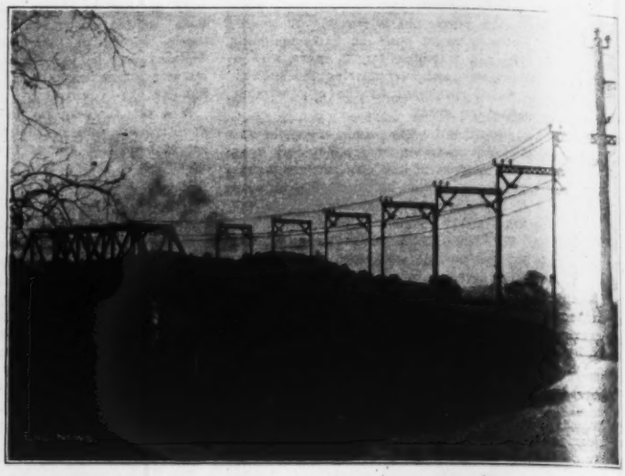
There are 65 miles of single track and at the Pittsburg end double track is laid for 11.5 miles. The maximum grade is 8%, though 5% is common. With the exception of four miles of 600-volt trolley at the Pittsburg end, the whole system is operated at 1,200 volts. Grooved 0000 trolley wire is used, strung double over the entire line. The overhead construction with wooden poles is shown in Fig. 1. This is supplemented for trestles, etc., by steel supports, as shown in Fig. 2. In a few places the trolley wires are suspended between two poles by a span wire and at some turnouts a single pole between the tracks carries two brackets. The brackets are made by screwing a malleable-iron casting onto one end of a 2-in. pipe and onto the other end, a malleable flange. This flange is fastened to the pole by a through bolt and a lag screw. The insulators are of porcelain and are 5 ins. in diameter by 5 ins. high. From Fig. 1 it might appear that the short span wire was wrapped in a groove at the middle of the insulator, but the part above the span wire is in reality a "petticoat" or "umbrella." The insulator pin is a metal pipe screwed into the end casting and holds the insulator by a flared end, fitting a recess in the porcelain. The insulators are also cemented to the pins.

The road has in use 14 four-motor passenger cars, of the usual interurban type. Two cars for freight service will be operated shortly. The motors, of interpole design, are connected in two groups of two in series, this grouping being the same for the 600 and 1,200-volt lines. The commutating fields are permanently connected in series with the armature. The motor groups are connected in series and parallel for starting and running respectively. This necessitates running at half the maximum speed while on the 600-volt lines. The control is practically the standard "type M" of the General Electric Co. With this, the main circuits are opened and closed by contactors under the car body and the main current does not come to the motorman's master controller. When the cars are on the 1,200-volt lines, current for lights, for the air compressor and the control circuits is furnished, at 600 volts, by a dynamotor.

Power is generated at Harmony Junction by two 1,500-KW., three-phase, 60-cycle Curtis-turbine units and is transmitted at 13,200 volts to substations at Shenango and Perrysville. The transmission line, 41 miles long, consists of three seven-strand aluminum cable, having the resistance of No. 2 B. & S. gage, copper wire. The cross-arm for this line is a malleable casting fastened to the pole by a through bolt and a lag screw. The top pin is also a malleable casting forming a weather cap for the pole. The insulators are of porcelain tested to 30,000 volts. In each substation are two 200-KW. 600-volt direct-current generators, coupled to a 425-KW. synchron-

*From information furnished by the General Electric Co., Schenectady, N. Y.





FIGS. 1 AND 2. OVERHEAD-LINE CONSTRUCTION FOR A 1,200-VOLT DIRECT-CURRENT RAILWAY.
Pittsburg, Harmony, Butler & New Castle Ry.

ous motor. The armatures are connected in series to give the desired line voltage. A substation outfit is installed at the power-house also, to serve the control part of the system.

Fourth Progress Reports of the International Waterways Commission. International Boundary at the Great Lakes; Diversion of Water from Niagara Falls.

Report to the Secretary of State.

By the provisions of a treaty between the United States and Great Britain, signed April 11, 1908, the International Waterways Commission was authorized to ascertain and reestablish the location of that part of the international boundary which passes through the Great Lakes, beginning at the St. Lawrence River near the 45th parallel of latitude and extending to the mouth of the Pigeon River at the west shore of Lake Superior. This commission is composed of Geo. C. Gibbons (Chairman Canadian Section), Louis Coste, Wm. J. Stewart, for the Dominion, and of O. H. Ernst (Chairman American Section), Geo. Clinton, E. E. Haskell, for the United States.

The report states that the charts of the Lakes as prepared by the Lake Survey, while serving admirably for navigation, are too old and inaccurate for giving to this area proper place on the earth's surface. Concerning the new charts the report says:

The preparation of a set of special charts has, with your approval, been undertaken in the office of the American Section at Buffalo, under the joint supervision of the Commission. They are to be of the uniform size of 40 × 50 ins. within the border. The scale adopted for the delineation of the rivers and of Pigeon Bay is 1/20,000; that for the head of the St. Lawrence River, the foot of Lake Ontario, the east and west ends of Lake Erie, Lake St. Clair, False Detour Passage, and the east end of Lake Superior is 1/60,000; that for Lakes Ontario, Erie, Huron and Superior 1/300,000; and for the immediate vicinity of Niagara Falls and Sault Ste Marie 1/10,000. The charts will show the shore lines of the lakes, rivers, islands, and the mouths of the more important streams; the location of all the principal cities and towns and of all the light-houses and other permanent aids to navigation; all hydrography available from the Canadian and United States surveys; all the geographic positions upon which the projections are based; and the boundary line, with all monuments, ranges, buoys, etc., used to mark it; unnecessary topography will be omitted. They will be projected and drawn directly upon copper plates, from which exact copies may be made in any desired number. Distortion of scale and errors in copying will thus be avoided. One set of copper plates having been prepared, a duplicate set will be made by electrotyping, and one set then deposited in the archives of each government. The data for these charts, with the exception of the new field work on the Canadian shores above mentioned, are in the Engineer Bureau of the War Department, and in the office of the Canadian Hydrographic Survey. Under authority of the honorable Secretary of War, the Chief of Engineers, U. S. Army, has placed at the disposal of the Commission the original large-scale manuscript charts constructed in the office of the Lake Survey, and other records of his bureau. The prompt and cheerful manner in which he has answered all calls for information deserves and receives the thanks of the Commission.

In an appendix to this report is a preliminary report to the American Secretary of State and to the Canadian Minister of Public Works on the preliminary estimate for the work called for in the treaty of April 11, 1908. It is proposed to have 30 charts showing the area involved. The estimated cost of the chart work is $60,000 and of marking the boundary at $100,000. This expense is to be equally shared by the United States and Canada.

Report to the Secretary of War.

This report deals largely with the water-power situation in the Niagara Falls District. The first matter taken up was in regard to a bill introduced into the 59th Congress, authorizing the Lower Niagara River Power and Water Supply Co. to divert 40,000 cu. ft. of water per second. The Commission, on March 3, 1908, forwarded to Mr. T. E. Burton, Chairman of the House Committee on Rivers and Harbors, recommendations which are interesting in the light of the later observations on the effect of diverting water for power and because of the treaty signed Jan. 11, 1909. Part of these recommendations we reprint:

In our report to the two Governments dated May 3 1906, we recommended that the total amount of water to be diverted from the Niagara River above the Falls should not be allowed to exceed 64,500 cu. ft. per sec., of which 28,500 cu. ft., including 10,000 cu. ft. for the Chicago Drainage Canal, was to be diverted on the American side and 36,000 cu. ft. on the Canadian side. These numbers were fixed by the special conditions of the case, and are not to be taken as a guide in fixing the amount of water which may properly be diverted from the Niagara River elsewhere or in dividing it between the two countries. The preservation of the rapids of Niagara River above and below the whirlpool is in our judgment of nearly as great importance to the esthetic education of the people as is the preservation of the Falls themselves. In both cases their grandeur is dependent upon their volume. In this case it is not necessary, and in our judgment it is not expedient, to allow the diversion of an amount which shall in any sense be experimental. It is our opinion that about 40,000 cu. ft. per sec. can be diverted without perceptible injury to the rapids, and that any amount greater than that will approach the danger line more and more nearly according to its volume. We therefore recommend that no more than 40,000 cu. ft. be diverted on both sides of the river taken together.

The general rule which should govern the diversion of the water between the two countries is that each side should be entitled to one-half. In the absence of a treaty between the two governments to regulate the diversion of water from the Niagara River, Congress should not, in our judgment, dispose of more than half of the total; that is, in this case, 20,000 cu. ft. per sec. If no other company is to be provided for, there seems to be no objection to the passage of the bill referred to us, after cutting down the quantity of water to be allowed to 20,000 cu. ft. per sec.

During the summer of 1908 the works of the Niagara Falls Power Co. were shut down on three occasions (June 14, July 19 and Aug. 1). The Commission, having been notified in advance, made observations of the effect of the diversion or non-diversion of the water used by that company, on the Niagara River and Falls. Water gages were installed at and above the Falls, and these were observed before, during and after the shut downs. A storm on Lake Erie masked the effects of the shut down of June 14, but good observations were secured on the other dates. On July 19 the plant of the one other power company on the American side (the Niagara Falls Hydraulic Power and Manufacturing Co.) was almost completely shut down. The readings were taken on staff gages by special observers secured for the occasions. A small error on this account is expected.

The report states that in 1907 the Lake Survey determined that the relative amount of water going over the American Fall was 4.85% of the total river discharge, the remainder going over the Horseshoe Falls on the Canadian side. The observations during the shut-down periods show that, of the water diverted by the American companies, about these same proportions would have passed over the respective falls. The report of Mr. W. E. Wilson, Secretary of the American Section, on this work, is reprinted nearly in full in what follows. This report is divided into sections on (1) the condition of the tunnel of the Niagara Falls Power Co.; (2) the quantity of water required to generate one horsepower in power-houses No. 1 and No. 2 of this company, and (3) the effect on the Niagara River and Falls of shutting off water from the plants on the American side.

CONDITION OF THE TUNNEL OF THE NIAGARA FALLS POWER COMPANY.—On June 14, 1908, the Niagara Falls Power Co. closed down their plant, to allow the International Railway Co. to inspect the American abutment of the steel arch bridge, which is located near the outlet of the Niagara Falls Power Co.'s tunnel, the railway company being of the opinion that the abutment might be undermined, due to erosion, caused by the discharge of water from the tunnel. This shutdown also gave the Niagara Falls Power Co. an opportunity to inspect the general condition of its tunnel. Accordingly, at 1.30 a. m. of the above date, the Niagara Falls Power Co.'s plant was closed down and the tunnel drained. Shortly thereafter, General Manager Philip P. Barton, Major Charles W. Kutz, Corps of Engineers, U. S. Army, and the writer, made an inspection trip of the tunnel, entering through the power plants of the company, located on the north shore of the Niagara River, adjacent to the pool immediately above the rapids approaching the Falls. The water used by this company is extracted from the river through a forebay and large intake, passed through the turbines of the separate power houses, discharged into two separate wheel pits, and thence carried by separate tunnels therefrom, which intersect at a point about 6,874 ft. from the portal of the tunnel, whence it is discharged

[*For the history of the construction for this hydraulic development see Engineering News, Jan. 23, 1896, May 24, 1894, and July 3, 1902.—Ed.]

into t... river. The tunnel is 6,917 ft. in length, from ... h end of wheel pit No. 1 to the outlet, and 7,548 ... the north end of wheel pit No 2 to the outlet ... an average height of 21 ft., 0.25 in. and a ma... width of 18 ft. 10 ins., with a circular top of ap... tely 11 ft. 2½ ins. radius, and an invert at the b... hose inverse side is about 11¼ ins. From the o... the outlet of the tunnel, which ends about 205 ... the face of the portal of masonry, the slope ... tunnel to station 52 + 0 is 0.7%; from station ... tation 68 + 73.5 (the intersection of the tunnels f... wheel pit No. 1 and wheel pit No 2) the slope is 0.4...

Power-... use No. 1 began operation Aug. 25, 1895, and power-... No. 2, Oct. 31, 1902. During this period, with one exception, when a shutdown was made several years ago for the purpose of inspecting the tunnel, the quantity of water discharged has reached several thousand cubic feet per second, flowing with a velocity of 20 to 20 ft. per sec. in the tunnel, which, at various times, has carried the ice that was discharged through the ice spillway into the tunnel. The lining of the tunnel is made up of several courses of vitrified brick, set in joints of Portland cement mortar, the inside surface being made as smooth as possible. From wheel pit No. 1 to the mouth of the tunnel, the condition of the lining was excellent. No erosion was noticeable at any place, the inside of the tunnel being covered with a very thin, green, slimy deposit. Opposite the outlet of the International Paper Co.'s tunnel, which intersects the main tunnel about two-third of the distance from the mouth, a slight pitting of the brick surface was noticed, which was said to have been caused by blasting in the paper mill tunnel during construction. It was stated by the general manager that this same condition was noticed several years before, during a prior shutdown. From the intersection of the tunnels from wheel pits Nos. 1 and 2 to wheel pit No. 2, the lining was broken in two places; one point, about 25 ft. above the intersection of the two tunnels, and the other at the junction of the tunnel with wheel pit No. 2. The breaks in the tunnel lining occurred in the roof in both instances. In the first case, bricks had been torn out and dropped into the tunnel for a distance of about 25 ft. In the second break, the entire roof had been ripped out for a distance of 10 or 11 bents, occupying approximately 100 ft. linear, the roof falling in large blocks, the largest of which contained about 2 cu. yds., the bricks and cement forming a solid monolith. An inspection of these blocks, which were still in the invert of the tunnel, showed that the break in the roof of the tunnel had occurred several years ago, as the exterior fractured surfaces were well waterworn. The breaks in the roof are attributed to the discharge, during the first winter that power-house No. 2 was in operation, of large blocks of ice through the ice chute into the tunnel, which was accompanied by a large unbroken sheet of water, in which air was entrailed, and carried into the tunnel. At short intervals, during this period, explosions occurred, which shook the windows in power-house No. 2. These explosions ceased after a buffer or gridiron of steel rails was placed in the ice chute, whereby the ice and the sheet of water were broken and the entrailed air allowed to escape before reaching the tunnel.

The inspection of the American abutment of the steel-arch bridge showed some slight erosion to the concrete retaining wall that had been placed near the outlet of the tunnel when the bridge was built, and resulted in the International Railway Co. constructing, between July 19 and July 28, 1908, an additional buffer, or concrete retaining wall, placed outside on the north end of the abutment, to prevent further erosion of the original retaining wall by the water discharged from the tunnel.

QUANTITY OF WATER REQUIRED TO GENERATE ONE ELECTRICAL HORSEPOWER IN POWER-HOUSES 1 AND 2 OF THE NIAGARA FALLS POWER CO.—On page 7 of the report by Capt. Charles W. Kutz, Corps of Engineers, U. S. Army, dated Oct. 5, 1905 (being a part of the report upon the existing water-power situation at Niagara Falls, so far as concerns the diversion of water on the American side), the following extract is quoted from section 9:

> As a result of more or less recent tests made by the engineers of the power company, it was determined that an average in the two power-houses of 0.101 cu. ft. of water per second was required to develop one electrical horsepower at the switchboard. If this determination is correct, the development of 100,000 E. HP., the nominal capacity of the plant would require 10,100 cu. ft. of water per second. This amount exceeds by 1,500 cu. ft. the amount computed as necessary under the assumed efficiency of the turbines and theoretic effective heads noted above.

The nominal capacity of power plants 1 and 2 has been stated to be 100,000 HP., but up to date the maximum amount of electrical horsepower actually developed, measured at the switchboard, was 82,460, which occurred about 5.30 p. m., Oct. 27, 1905. No current meter measurements of the total flow of water were made in the canal at this time, so that the only method of determining the quantity actually used depends upon the turbine rating curves of one wheel in each power-house.

That 100,000 HP. has never been developed is due to the fact that the tunnel can not discharge the quantity of water required to generate the power under existing conditions. The tunnel was originally designed to carry the water from the wheels at an average velocity of about 25½ ft. per second. In order for the water to attain this velocity, head must be created in the wheel pits, which necessarily reduces the effective head under which the turbines operate, thus decreasing the efficiency of the plant.

TABLE I.—WATER REQUIRED TO GENERATE 1 ELECTRICAL HORSEPOWER IN POWER-HOUSES NOS. 1 AND 2 OF THE NIAGARA FALLS POWER CO. AT 10 A. M., JUNE 13, 1908.

Unit.	Load, KW.	Load, E.HP.	Elevation, head water.	Elevation, tail water.	% Mean head on turbines.	% Rated efficiency of turbines.	Sec.-ft. of water used, determined by— Turbine rating.	Current meter measurement.	Sec.-ft. of water required to generate 1 E. HP. Turbine rating.	Current meter measurement.
Power-house No. 1:										
1	2,880	3,860	560.4	419.8	135.4	52.9	474	....	0.123	0.128
2	2,880	3,860	560.4	420.5	135.4	52.9	474	....	0.123	0.128
3	3,080	4,130	560.4	421.7	135.4	55.6	483	....	0.117	0.122
4	....	....	560.4	422.8	....	....	....	....	....	....
5	3,600	4,830	560.4	423.8	135.4	62.0	506	....	0.105	0.110
6	2,760	3,700	560.4	424.4	135.4	51.3	469	....	0.127	0.132
7	2,720	3,650	560.3	424.7	135.3	50.8	467	....	0.128	0.133
8	2,680	3,590	560.3	425.0	135.3	50.1	466	....	0.130	0.135
9	....	....	560.4	425.3	....	....	....	....	....	....
10	3,200	4,290	560.4	425.7	134.7	57.1	491	....	0.114	0.119
Total	23,800	31,910	....	....	....	....	3,830	3,995	0.120	0.125
Power-house No. 2:										
11	3,560	4,770	560.6	423.9	136.7	71.5	429	....	0.090	0.094
12	3,720	4,990	560.6	423.9	136.7	72.9	441	....	0.088	0.092
13	3,460	4,640	560.6	423.9	136.7	70.7	422	....	0.091	0.095
14	3,600	4,830	560.6	424.0	136.6	71.9	433	....	0.090	0.094
15	3,500	4,690	560.6	424.0	136.6	71.0	426	....	0.091	0.095
16	3,560	4,770	560.6	424.0	136.6	71.5	430	....	0.090	0.094
17	....	....	560.6	423.6	....	....	....	....	....	....
18	3,320	4,450	560.6	423.2	137.4	69.5	410	....	0.092	0.096
19	3,220	4,320	560.6	422.8	137.8	68.5	403	....	0.093	0.097
20	3,300	4,420	560.6	422.3	138.3	69.2	406	....	0.092	0.096
21	3,080	4,130	560.6	421.9	138.7	67.4	389	....	0.094	0.098
Total	34,320	46,010	....	....	....	....	4,189	4,370	0.091	0.095
Grand total	58,120	77,920	....	....	....	....	8,019	8,365	....	....

On June 13, 1908, at 10 a. m., the Niagara Falls Power Co. had a load on their two power plants of 77,920 E. HP., measured at the switchboards. During this time, the United States Lake Survey made current meter measurements of the quantity of water actually being used by the power company to develop this quantity of power. The writer has also obtained from the company the load upon the individual generators, the head acting on the turbines and their rated efficiency for various outputs of power.

The hydraulic data and loads on the several turbines in power-houses Nos. 1 and 2, taken during this extremely heavy output on the above-mentioned date, have been reduced and are given in Table I.

A reduction made by the rating tables of the two turbines in power-houses 1 and 2 gives the quantity of water used by the 8 turbines in power-house No. 1 as 3,830 cu. ft. per sec., and by the 10 turbines in power-house No. 2 as 4,189 cu. ft. per sec., a total of 8,019 cu. ft. The quantity of water actually used, as measured by the United States Lake Survey, was 8,475 cu. ft. per sec., from which should be deducted 35 cu. ft. per sec. as the quantity used in the exciter turbines, and about 75 cu. ft. per sec., the quantity of water used by the Niagara Falls Water-Works Co. (see page 7 of report on water-power situation at Niagara Falls, so far as concerns the diversion of water on the American side, sections 11 and end of section 12), which leaves 8,365 cu. ft. passing through the turbines. Assuming that the amount of water actually used by the turbines in power houses 1 and 2 is proportional to the difference in the current meter measurement and the amount determined by the rating curve, we have $\frac{4,189 \times 8,365}{8,019} = 4,370$ cu. ft. per sec., the quantity of water actually used in the turbines in power-house No. 2 and $\frac{3,830 \times 8,475}{8,019} = 3,995$ cu. ft. per sec., the quantity of water actually used in the turbines in power-house No. 1, a difference of approximately 4% between the discharge as computed by the turbine ratings and the discharge as actually measured. This table is one of many which could be computed to determine the actual quantity of water that could flow through the Niagara Falls Power Co.'s tunnel with varying amounts of power developed. The results given herein hold for this condition only and should not be taken as a definite ratio until further observations have been reduced.

The efficiency of the turbines decrease very rapidly when they are operated on part load, and any determination of the quantity of water required to generate one electrical horsepower should be determined when the plant is operated at its full instead of part load. A determination made at part load gives a much larger quantity of water per horsepower than under full load, which if used to compute the capacity of the plant would be in considerable error. Table No. 1 shows that under the conditions at time of measurement a load of 4,800 HP. on a generator in power-house No. 1 required 0.110 cu. ft. per sec. per horsepower, whereas a load of 3,700 HP. required 0.132 cu. ft. per sec. per HP. In power-house No. 2, 5,000 HP. required 0.092 cu. ft. per sec. per HP., whereas 4,100 HP. required about 0.098 cu. ft. per sec. per HP. It is readily seen, therefore, that unless all of the turbines are loaded to their full capacity, which has not occurred to date, it will be very difficult to state the quantity of water in cu. ft. per sec. required to generate one horsepower. Under the conditions existing at time of measurement, an average load of 4,000 HP. per generator in power-house No. 1 required 0.125 cu. ft. per sec. to generate one horsepower, measured at the switchboard; while an average load of 4,600 HP. per generator in power-house No. 2 required 0.095 cu.-ft. per sec. to generate one horsepower.

THE EFFECT ON THE NIAGARA RIVER AND FALLS CAUSED BY THE SHUTTING OFF OF WATER FROM THE PLANTS ON THE AMERICAN SIDE OF THE NIAGARA RIVER.—Commencing at 7 a. m., June 13, 1908, the International Waterways Commission, in conjunction with the United States Lake Survey and the Niagara Falls Power Co. observed water levels at several points in the Niagara River. The gages are numbered as follows: Gage No. 1, South Pier, Buffalo Harbor, Buffalo, N. Y.; gage No. 2, foot of Austin St., Buffalo, N. Y.; gage No. 3, Chippewa Creek, Chippewa, Ontario; gage No. 4, Grass Island, Niagara Falls, N. Y.; gage No. 5, about 200 ft. east of the intake of the Ontario Power Company's plant, Niagara Falls, Ontario; gage No. 6, Willow Island, Niagara Falls, N. Y.; gage No. 7, Prospect Point, crest of American Falls, Niagara Falls, N. Y. These gages were read at ten-minute intervals for the following periods:

June 13, 7 a. m., to June 16, 7 a. m.
July 18, 8 a. m., to July 20, 12 midnight.
June 27, 8 a. m., to July 29, 12 midnight.
Aug. 1, 8 a. m., to Aug. 3, 4 p. m.

The following is a record of the operations of the Niagara Falls Power Company's power plant and the Niagara Falls Hydraulic Power & Manufacturing Company's power plant during the period from June 13 to Aug. 6, 1908, inclusive.

Record of the Niagara Falls Power Company's plant:
June 13, power-houses 1 and 2 in operation.
June 14, 1.30 a. m., power-houses 1 and 2 shut down.
June 14, 9 a. m., power-houses 1 and 2 in operation.
July 19, 1.30 a. m., power-houses 1 and 2 shut down.
July 19, 1.30 a. m., to July 28, 12.30 a. m., company constructed bulkhead in tunnel No. 2, at intersection of tunnels 1 and 2 with main tunnel.
July 28, 12.30 a. m., power-house No. 1 in operation.
July 28, 12.30 a. m., to Aug. 1, 11.30 p. m., power-house No. 1 in operation, power-house No. 2 shut down. Company repairing tunnel leading to wheelpit No. 2.
Aug. 1, 11.30 p. m., power-houses 1 and 2 shut down and company started to remove bulkhead.
Aug. 2, 7.30 p. m., power-houses 1 and 2 in operation.

Record of Niagara Falls Hydraulic Power & Manufacturing Company's Power plant:
June 13, plant in operation.
June 14, 6.30 a. m., entire plant closed, with exception of about 280 cu. ft. per sec. flowing in canal.
June 14, 9.30 a. m., power plant in operation.
July 19, 1 a. m., plant closed down to about 500 cu. ft. per sec.
July 19, 5 a. m., plant closed down to about 300 cu. ft. per sec.
July 19, 8 a. m., plant in operation.

At the time of the shutdown, June 14, a severe storm occurred on Lake Erie, which raised its level about 2 ft. and masked the effects of the diversion of water by the power companies on the pool above the falls and on the American falls. The amount of water diverted by the Niagara Falls Power Co. was determined by current

meter measurement, and that by the Niagara Falls Hydraulic Power & Manufacturing Co. from results deduced by the company.

In determining the effect of this diversion of water, a comparison was made of the slope in the Niagara River from Buffalo, N. Y., to the several gages at Niagara Falls; first under the condition when the plants were shut down; secondly, when they were in operation. In

FIG. 1. GAS AND DUST GALLERY NO. 1, U. S. GEOLOGICAL SURVEY TESTING STATION AT PITTSBURG, PA.

all cases the fall of the river from Buffalo to these gages increased during the period that the power plants were in operation, which varied with the quantity of water being diverted from the pool.

Table II. gives the absolute change in the fall from Buffalo to the several gages, with the corresponding change in the amount of water diverted through these power plants:

Table II.—Change in Fall Along Niagara River.

Date. 1908.	Gage.	(a) Cu. ft. per sec.	(b) Ft.
July 18-19	No. 3, Chippewa	8,210	0.076
July 18-19	No. 4, Grass Island	8,210	.256
July 18-19	No. 5, Ontario Intake	8,210	.112
July 18-19	No. 6, Willow Island	8,210	.072
July 18-19	No. 7, Prospect Point	8,210	.044
July 27-28	No. 3, Chippewa	5,300	.012
July 27-28	No. 4, Grass Island	5,300	.168
July 27-28	No. 5, Ontario Intake	5,300	.059
July 27-28	No. 6, Willow Island	5,300	.037
July 27-28	No. 7, Prospect Point	5,300	.015
August 1-2	No. 3, Chippewa	6,380	.140
August 1-2	No. 4, Grass Island	6,380	.241
August 1-2	No. 5, Ontario Intake	6,380	.080
August 1-2	No. 6, Willow Island	6,380	.088
August 1-2	No. 7, Prospect Point	6,380	.022
August 2	No. 3, Chippewa	5,890	.066
August 2	No. 4, Grass Island	5,890	.210
August 2	No. 5, Ontario Intake	5,890	.082
August 2	No. 6, Willow Island	5,890	.061
August 2	No. 7, Prospect Point	5,890	.025

(a) Change in quantity of water diverted from river by American power plants; (b) corresponding change in fall from Buffalo to the several gages in Niagara River.

The maximum effect of the diversion occurred at gage No. 4, Grass Island, located near the intake of the Niagara Falls Power Co. The fluctuations in gage No. 3, located at Chippewa, Ontario, were, apparently, not consistent. The effects on the other gages decreased in the following order: Gage No. 5, Ontario intake; gage No. 6, Willow Island; and gage No. 7, Prospect Point, crest of American Falls.

CONCLUSIONS.—The conclusions reached may be summarized as follows:

(1) The tunnel of the Niagara Falls Power Co. showed no apparent erosion from the friction of the water with the lining.

The breaks in the tunnel from wheel pit No. 2 to the intersection of tunnels Nos. 1 and 2 with main tunnel were probably caused by ice with entrained air, which was carried into the tunnel during the period of ice sluicing the first winter that power house No. 2 was in operation.

An additional retaining wall, or buffer, was constructed to prevent further erosion of the original retaining wall which had been built for the protection of the American abutment of the steel arch bridge at Niagara Falls.

(2) The maximum quantity of water required for a maximum load, in power houses Nos. 1 and 2 of the Niagara Falls Power Co., to generate 1 electrical horsepower measured at the switchboard, is unknown until a complete investigation of the subject has been made, which is not within the scope of this report.

0.125 cu. ft. of water per second per E. HP., measured at the switchboard, was required on June 13, 1908, to develop an average load of 4,000 electrical horsepower on eight generators in power-house No. 1 of the Niagara Falls Power Co.

0.095 cu. ft. of water per second per E. HP., measured at the switchboard, was required on June 13, 1908, to develop an average load of 4,600 E. HP. on 10 generators in power house No. 2 of the Niagara Falls Power Co.

(3) The surface of the Niagara River is lowered by the diversion of 8,000 cu. ft. of water per second through the plant of the Niagara Falls Power Co. and that of the Niagara Falls Hydraulic Power and Manufacturing Co. by the following amounts:

	Ft.
Gage No. 4, Grass Island, near intake of the Niagara Falls Power Co.	0.271
Gage No. 5, near Ontario intake	.104
Gage No. 5, Willow Island	.078
Gage No. 7, Prospect Point, crest of American Falls	.031

(4) In 1907 the United States Lake Survey determined that the relative amount of water flowing over the American Falls was about 4.85% of the total volume of the discharge of the river, the remainder going over the Horseshoe Falls.

The amount the water is lowered on the crest of the American Falls when 8,000 cu. ft. per sec. is being taken by the American power plants is, therefore, small. When these plants are closed down, only approximately 5% of this 8,000 passes over the American Falls. This fact is substantiated by the nearly equal rise of 0.10 ft. in the water surface at gage No. 5, located near the Ontario intake on the Canadian side of the river, and that of 0.08 ft. rise at gage No. 6, located at Willow Island on the American side. These gages are situated about equal distances from the crest of the rapids approaching the falls.

Treaty of Jan. 11, 1909.

A treaty popularly known as the "waterways treaty" was signed by Elihu Root, American Secretary of State, and James Bryce, British Ambassador, on Jan. 11, 1909. No c[opies] of this treaty have been given out nor will [any official] statement of the text be made until [the Senate] has ratified it and removed the i[njunction] of secrecy. Current press reports, ho[wever, state] that the treaty provides generally f[or] the disposition of all differences, that may ar[ise] between the two countries, by a joint high c[ommission]. It is stated that the treaty also speci[fically con]siders the problems of fixing the in[ternational] boundary in the great lakes and the [amount of] water to be diverted from Niagara [Falls and] the adjacent rapids. It is stated that [the joint] high commission will supersede the p[resent In]ternational Waterways Commission.

The amounts of water which the tre[aty] allows to be diverted from the Niagara Falls is stated in these current reports to be 20,000 cu. ins. per sec. from the American side, 36,000 cu. ins. per sec. from the Canadian side, and 10,0[00] cu. ins. per sec. for the Chicago Drainage Ca[nal]. This, it is said, would allow a possible de[velopment] of 236,000 HP. on the American side and of 425,000 HP. on the Canadian side. However, the experience of the Niagara Falls Power Co., as shown in the foregoing reports, would reduce these figures to about 200,000 and 360,000 HP. respectively.

Government Tests of Explosives for Coal Mining.

Now that a series of preliminary tests of the effects of firing explosives in the presence of coal dust and inflammable gas has been completed, it is announced that the U. S. Geological Survey Testing Station at Pittsburg, Pa., will begin official tests of explosives to be submitted by manufacturers. These tests will be made to determine whether the explosives are permissible for use in mines containing gas, dust or a combination of the two in dangerous quantities.

The tests are made in a boiler plate cylinder, 6 ft. in diameter and 100 ft. long. Shelves are provided along the sides of the cylinder upon which to place the coal dust and in one side are portholes covered with ½-in. glass through which the results of each test may be watched from an observation house built parallel to the cylinder at a distance of 60 ft. Natural gas is used to take the place of the fire damp found in coal mines, as it has approximately the same chemical composition, and suitable provision is made for pumping any desired mixture of gas and air into the cylinder. The gas pipes and peep holes are easily distinguishable in Fig. 1. The explosive under test is charged into a cannon mounted within the cylinder and the shot is fired by electricity from the observation house. Hinged openings are

FIG. 2. MINE EXPLOSIVES TESTING GALLERY: SHOWING ACTION OF RELIEF DOORS DURING COAL DUST EXPLOSION.
(Photograph taken 15 seconds after ignition.)

provided in the roof of the tube which act as safety valves in case of ignition of the dust or gas. Fig. 2 is reproduced from a photograph taken 1/10 seconds after an explosion of coal dust and shows clearly the action of these relief doors.

Manufacturers are required to furnish 100 lbs. of each explosive they desire to have tested, and

	Per cent.
Nitroglycerine	40
Nitrate of sodium	44
Wood pulp	15
Calcium carbonate	1
	100

Each shot shall be fired with an electric fuse of sufficient power to completely detonate or explode the charge,

FIG. 3. INTERIOR OF GLASS-ENCLOSED ROOM ARRANGED FOR PRACTICE IN MINE RESCUE WORK.

no one will be allowed to witness or participate in the tests of any explosive except the Government officials and the manufacturer's representative. The following list of test requirements has been issued by the Director of the U. S. Geological Survey:

Test 1.—Ten shots with the charge as described above, in the original wrapper, shall be fired, each with 1 lb. of clay tamping, at a gallery temperature of 77° F., into a mixture of gas and air containing 8% of methane and ethane. An explosive will pass this test if all ten shots fail to ignite the mixture.

Test 2.—Ten shots with charge as previously noted, in its original wrapper, shall be fired, each with 1 lb. of clay tamping at a gallery temperature of 77° F., into a mixture of gas and air containing 4% of methane and ethane and 20 lbs. of coal dust, 18 lbs. of which is to be placed on shelves laterally arranged along the first 20 ft. of the gallery, and 2 lbs. to be placed near the inlet of the mining system in such a manner that all or part of it will become suspended in the first division of the gallery. An explosive will pass this test if all ten shots fail to ignite the mixture.

Test 3.—Ten shots with charge as previously noted, in its original wrapper, shall be fired, each with 1 lb. of clay tamping at a gallery temperature of 77° F., into 40 lbs. of bituminous coal dust, 20 lbs. of which is to be distributed uniformly on a horse placed in front of the cannon and 20 lbs. placed on side shelves in sections 4, 5 and 6. An explosive will pass this test if all ten shots fail to ignite the mixture.

Test 4.—A limit charge will be determined within 25 gms., by firing charges in their original wrappers unstemmed at a gallery temperature of 77° F., into a mixture of gas and air containing 4% of methane and ethane and 20 lbs. of bituminous coal dust, to be arranged in the same manner as in test 2. This limit charge is to be repeated five times under the same conditions before being established.

Test 5.—A limit charge will be determined under the same conditions as in test 4, except that 2% of methane and ethane will be used instead of 4%.

Note: At least 2 lbs. of clay stemming will be used with slow burning explosives. The charge of explosive, to be fired in tests 1 and 2, shall be equal in disruptive power to ½ lb. of nitroglycerine dynamite in its original wrapper, of the following formula:

as recommended by the manufacturer. The explosives must be in such condition that the chemical and physical tests do not show any unfavorable results. The explosives in which the charge used is less than 100 gms. will be weighed in tin foil without the original wrapper.

The dust used in tests 2, 3, 4 and 5 will be of same degree of fineness and taken from one mine.

In making the tests, precedence will be given to explosives already on the market, and a bulletin will be issued recommending as permissible explosives such as prove satisfactory. The results of all tests will be called directly to the attention of the state mining bureaus and mine operators.

In addition to the tests of explosives, elaborate experiments have been made at the testing station in rescue work. One part of the station is arranged to represent a miniature coal mine. A large glass-walled, air-tight room is arranged with difficult passages and obstructions such as are found in coal mines after an explosion and dummies weighing 150 to 200 lbs. are used to represent injured miners. The room is filled with gas, and men of the rescue corps are trained in the use of the oxygen helmet apparatus. An idea of the care taken to reproduce actual conditions in this practice work may be gained from Fig. 3. The Government does not expect to furnish rescue corps for every mine, but has organized the present corps with the idea of encouraging the formation of private rescue crews by the individual mining companies, many of which have already sent men to the testing station to be trained for this purpose.

A SNOWSLIDE WRECKED A TRAIN on the Canadian Pacific Ry., 110 miles east of Vancouver, B. C., Jan. 15. The accident occurred in the Fraser Cañon and it is reported that the entire train, including its two locomotives, was forced from the track by the snow and fell into the Fraser River, 80 ft. below. Both engineers were killed and 33 passengers were injured.

THE "KATY FLYER" was derailed on the Missouri, Kansas & Texas Ry., at Beagle, Kan., Jan. 17, by splitting a switch. The locomotive broke away from the train and struck a work car on a siding 40 ft. distant. The engineer of the "Flyer" and five of the 30 track laborers who were sleeping in the work car were killed. None of the passengers were injured.

A DISASTROUS RAILWAY ACCIDENT took place Jan. 15 on the Denver & Rio Grande R. R., near Dotsero, Colo., 110 miles west of Denver. Twenty-one persons were killed and forty others were severely injured. Passenger train No. 5, westbound, was under orders to meet an eastbound freight train at Dotsero siding. The passenger train, however, passed the siding at a speed estimated as 45 mi. per hr., and the collision occurred immediately west of the siding, which the freight train had not quite reached. There was a considerable down grade from east to west at the point where the accident occurred, and the freight was drawn by two locomotives. Both of these and the passenger locomotive were stood up on end and crushed together. The passenger train was made up, in the order named, of a baggage car, smoking car, chair car, tourist sleeper and lastly several Pullman sleepers. The smoker was only partially derailed but the chair car just behind it (corresponding in construction to the day coach of the East) was telescoped by the tourist sleeper and is described as being split in half for practically its entire length. Most of those killed were in the chair car. The Pullman sleepers were not even derailed and none of their passengers were injured.

The official explanation of the accident places the responsibility with the engineer and conductor of the passenger train. Both of these men, who have been in the service of the Denver & Rio Grande since 1887, will survive the collision and an inquest will be held as soon as the engineer, now in a hospital, is able to testify. Reports state that the engineer claims to have mis-read his watch and assumed that he had time to meet the freight at the next siding beyond Dotsero.

AN ABANDONED COAL MINE COLLAPSED near Snydertown, Pa., Jan. 17. Several hundred yards of roadway on the surface dropped about 3 ft. and deep fissures appeared in the adjacent ground. Several barns and residences were damaged.

A COAL MINE EXPLOSION AT VESZPRIM, Hungary, 60 miles southwest of Budapest, Jan. 14, entombed about 240 miners. It is hoped, however, that most of these can be rescued. The accident occurred in the Auka coal mine and is described as an explosion of fire-damp followed by a dust explosion and fire. Sixteen men have been rescued and 45 dead bodies have been removed from the mine.

THE CLOSURE OF THE LAGUNA DAM was completed on Dec. 21, 1908, by the U. S. Reclamation Service. Preparations for the closure were completed on Dec. 9, and the dumping of rock by two steam shovels on the California side and five derricks on the Arizona side was begun. At noon on Dec. 21 the whole river was diverted through the sluiceways, and since that date the closure works have successfully withstood a flood of 40,000 sec.-ft. Two articles on the Laguna Dam were published in our issue of Feb. 27, 1908. The foregoing particulars regarding the closure are taken from advance sheets of the "Reclamation Record."

THE ROOSEVELT DAM, now being constructed by the U. S. Reclamation Service in Arizona, was carried to an average elevation of 85 ft. in December, during which month 12,500 cu. yds. of masonry were placed. On Dec. 16-17 a flood passed over the highest part of the dam. The cement mill connected with this irrigation project burned 5,100 bbls. and ground 5,079 bbls. during December. Progress on this dam was described in some detail in our issue of Sept. 10, 1908. The foregoing particulars are taken from advance sheets of the "Reclamation Record."

THE VALUATION AWARD of $1,975,000 for the water-works plant of the Monongahela Water Co., supplying the South Side of Pittsburg, Pa., has been affirmed by the Pennsylvania State Supreme Court. Bonds to the amount named were authorized by popular vote in November, 1908, and it is expected that these bonds will be advertised for sale within a few days and the proceeds thereof used to pay the award. It is also expected that, as soon as the city takes possession of the works, the South Side will be supplied with filtered water from the new filtration plant. The award was taken to the State Supreme Court by the city, which claimed that the award should not include the value of the franchises and the intangible assets of the company. The city lost this point.

A LARGE INCREASE IN IDLE CARS occurred in the two weeks Dec. 23, 1908, to Jan. 6, 1909. On the former date the figure was 222,077, and on the latter 333,019, an increase of 110,942, made up of 60,000 box cars, 40,000 gondola and coal cars, and 9,000 flat cars.

The increase was shared by all sections of the country. The greatest relative change was on the Canadian lines, where the surplus rose from 3,598 to 19,837 cars, the latter figure being in fact greater than the worst figure of April or May, 1907, when the surplusage was at its height.

THE STEINWAY TUNNEL under the East River at 42d St., New York, which had been offered to New York City for the price of about $7,000,000 by its owners, the Interborough Rapid Transit Co. (which owns the New York & Long Island R. R. Co., the original owners of the tunnel), has been refused by the Public Service Commission on the ground that the terms offered are unsatisfactory and the transaction would be unprofitable to the city. Prior to this the Commission had its Chief Engineer make an examination of the tunnel, and he found it in good condition, but requiring some $300,000 further expenditure to put it in operating condition; the terminal on the Manhattan side is poorly located, however. The Commission estimates that the annual cost of the tunnel to the city, about $350,000, would not be met by the revenue for many years to come.

ROAD MAINTENANCE in 72 county boroughs of England and Wales during the year 1905-06, according to Local Taxation Returns just published, cost a total of $6,165,527, or an average of $700 for 8,816 miles. This cost, according to the London "Surveyor" for Jan. 8, 1909, includes "maintenance and repair," but presumably makes no allowance for capital charges. Roads in non-county boroughs are also covered in the Returns. Of these, the maintenance and repair of 1,242 miles of "main roads" cost $1,271,585, or an average of $1,024. A total of 4,612 miles of other roads in non-county boroughs cost $2,330,803 for maintenance and repairs, or $505 per mile.

Personals.

Mr. J. P. Charlton, Supervisor at Morristown, Pa., will succeed Mr. Massey as Assistant Engineer at Reading, Pa.

Mr. Louis W. Hill, President of the Great Northern Ry., has been appointed a member of the State Highway Commission of Minnesota.

Mr. E. A. Walton, Division Superintendent of Motive Power of the New York Central & Hudson River R. R., at West Albany, N. Y., has resigned.

Mr. L. H. Conklin, Superintendent of the West Penn. Railways Co., with headquarters at Connellsville, Pa., has resigned to become General Manager of the Scranton Ry. Co., at Scranton, Pa.

Mr. Harry Stephenson, Auditor of the Western Ohio Ry. Co., of Lima, Ohio, will succeed Mr. W. L. Smith as Superintendent of the Toledo, Bowling Green & Southern Traction Co., with headquarters at Bowling Green.

Mr. Abbott Lawrence Lowell, Professor of the Science of Government at Harvard University, has been chosen by the university corporation to succeed Dr. Charles W. Eliot as President. Dr. Eliot's resignation is to take effect in May, 1909.

Mr. Herbert T. Herr, M. Am. Soc. M. E., has become General Manager of the Westinghouse Machine Co. He is the brother of Mr. E. M. Herr, M. Am. Soc. M. E., Vice-President and General Manager of the Westinghouse Electric & Mfg. Co.

Mr. W. C. Taylor, Assistant Chief Engineer of the Spokane, Portland & Seattle Ry., has been appointed Engineer of Maintenance of Way of that railway and of the Astoria & Columbia River R. R. His headquarters will continue to be at Portland, Ore.

Mr. Eugène H. Shipman, Chief Engineer of the Lehigh Coal & Navigation Co., has been appointed Superintendent of Canals of that company to succeed Mr. John Ruddle, M. Am. Soc. C. E., resigned. Mr. Shipman's office will be at Mauch Chunk, Pa.

Mr. Henry P. Louttit has resigned his position as Deputy State Mine Inspector of Pennsylvania and will be succeeded by Mr. William H. Howarth. Mr. Louttit's territory as inspector included the mines at Marianna, in which a serious explosion took place on Nov. 28, 1908.

Mr. L. M. Shipley, Superintendent of the Fort Dodge division of the Chicago Great Western Ry., has been appointed Superintendent of the Southwest division, with headquarters at Des Moines, Iowa, succeeding Mr. C. S. Weston, resigned. Mr. A. E. Harvey will succeed Mr. Shipley at Clarion, Iowa.

Obituary.

William C. Ambrose, M. Am. Soc. C. E., died Jan. 4 in Berkeley, Cal., at the age of 51 years.

Charles W. Atmore, a civil engineer and contractor of Philadelphia, Pa., died at his home on Haverford Ave. Jan. 17.

William C. Stimpson, head instructor in molding and forging in the Department of Science and Technology of Pratt Institute, Brooklyn, N. Y., died Jan. 13 in Milford, Conn. Mr. Stimpson was a graduate of Kansas State University, where he took the course in civil engineering, and he had taken some work as a special student at the Massachusetts Institute of Technology. He was a member of the American Foundrymen's Association and the National Society for the Promotion of Industrial Education.

George H. Middleton, a civil engineer well known in Canada and in South Africa, died recently in Edinburgh, Scotland. He was educated at St. Andrew's University, Scotland, and later studied engineering in the office of Mr. John Lang in Karkaldy. He came to Nova Scotia in 1870 and was subsequently engaged in engineering work for the Intercolonial Ry. in the St. Lawrence district, the Canadian Pacific Ry. in the region at the northern end of Lake Superior and finally for the Newfoundland Ry. His next work was in Natal, where he continued in railway construction throughout the South African War.

Jefferson Brown, Chief Engineer, retired, of the U. S. Navy, died at his home in Brooklyn, N. Y., Jan. 17, after an attack of pneumonia. He was born in New York City in 1841 and was educated in the public schools and afterward by private instructors. In 1862 he was appointed to the Engineer Corps of the U. S. Navy and, in the following year, while serving on the U. S. Ship "Mississippi," was made a prisoner in the battle of Port Hudson in which the vessel was destroyed. He was exchanged shortly afterward and served for some time on the ironclad, "Canonicus." For several years after the war he was Assistant Engineer at the Brooklyn Navy Yard. He was retired for physical disability in 1892 with the rank of Commander.

Brigadier-General William P. Craighill, U. S. A., died at his home in Charlestown, W. Va., on Jan. 18, after an illness of only a few days.

While General Craighill has been living in retirement for the past ten years, he was, during his active professional life, one of the best known of the officers of the Corps of Engineers. It is of interest to note that the latest years of his life were spent in his boyhood home. He was born on July 1, 1833, at Charlestown, then in the State of Virginia. He graduated from West Point in the Class of 1853, standing second in a class of 52 members. The class was notable for the proportion of its members who afterward acquired national fame in the struggles of the Civil War. Among them were Generals Sheridan, Schofield, McPherson and Terrill of the Union forces, and General Hood of the Confederate Army. General William Sooy Smith, the well-known civil engineer, was also a member of this class. On graduation Mr. Craighill received his commission in the corps of Engineers and a considerable part of his time previous to the outbreak of the Civil War was spent at Washington in the Engineer Bureau of the War Department, where General Totten was at the time Chief of Engineers. During the Civil War Colonel Craighill had charge of important fortification work including the defenses of Washington, Baltimore, Hampton Roads, Charleston and Savannah. After the war he began active service in connection with river and harbor improvements, and a considerable number of his assignments were in connection with the most important harbors of the Atlantic Coast. He also served for four years as one of the professors at the United States Military Academy and was for several years a member of the Lighthouse Board.

Colonel Craighill was elected to membership in the American Society of Civil Engineers in 1885. He served for two years as a member of the Board of Direction of the Society, and in 1894 was elected to its Presidency, and was the first, and so far the only, officer of the Corps of Engineers to hold that position. A portrait and biography of Colonel Craighill were published at the time of his election to the American Society Presidency in our issue of Feb. 15, 1904. Not long after that time Colonel Craighill was appointed to the office of Chief of Engineers and held that position until his retirement for age. Colonel Craighill was a man of most attractive social qualities as well as an able engineer. Following his retirement from the Engineer Corps, his name was prominently mentioned for other positions, among them the presidency of an important engineering school. He preferred, however, to spend the later years of his life in well earned quiet among the pleasant social surroundings of his childhood home.

Engineering Societies.

COMING MEETINGS.

OHIO ENGINEERING SOCIETY.
Jan. 26-28. Annual convention at Columbus, Ohio. Secy., Paul Hansen, Harrison Bldg., Columbus, Ohio.

ILLINOIS SOCIETY OF ENGINEERS AND SURVEYORS.
Jan. 27-29. Annual meeting at Chicago, Ill. Secy., E. E. R. Tratman, 1636 Monadnock Block, Chicago.

CANADIAN SOCIETY OF CIVIL ENGINE[illegible]
Jan. 28. Annual meeting at Toronto. [illegible] C. H. McLeod, 413 Dorchester St., W., Montr[illegible], P. Q.

NATIONAL BRICK MANUFACTURERS' A[illegible]IATION.
Feb. 1-6. Annual convention at Roch[illegible], N. Y. Secy., T. A. Randall, Indianapolis, Ind.

CONNECTICUT SOCIETY OF CIVIL ENGI[illegible]RS.
Feb. 9. Annual meeting at Hartford, [illegible] Secy., J. Frederick Jackson, Box 1304, New [illegible], Conn.

NEW ENGLAND GAS ASSOCIATION.
Feb. 17-18. Annual meeting at Boston, [illegible] Secy., N. W. Gifford, East Boston Gas Co., [illegible] Boston, Mass.

AMERICAN INSTITUTE OF MINING ENGI[illegible]ERS.
Feb. 23. Annual meeting at New Haven, [illegible]. Secy., R. W. Raymond, 29 West 39th St., New [illegible] City.

NORTHWESTERN CEMENT PRODUCTS [illegible]SSOCIATION.
March 2-4. Annual convention at Minnea[illegible], Minn. Secy., J. C. Van Doorn, 836 Security [illegible] Bldg., Minneapolis, Minn.

INTERSTATE CEMENT TILE MANUFA[illegible]URERS' ASSOCIATION.—The third annual convention will be held at Minneapolis, Minn., March 2, in conjunction with the annual convention of the Northwestern Cement Products Association.

IOWA ENGINEERING SOCIETY.—At the annual convention in Waterloo, Iowa, Jan. 13-14, officers for the ensuing year were elected as follows: President, C. T. Wilson, Waterloo; Vice-President, T. R. Warriner, Cedar Rapids; Secretary and Treasurer, A. H. Ford, Iowa City; Directors, L. H. Stone, Cedar Rapids, and C. P. Chase, Clinton.

ILLUMINATING ENGINEERING SOCIETY.—At the annual meeting in New York City, Jan. 8, officers were elected as follows: President, W. H. Gartley, Philadelphia; Vice-Presidents, C. O. Bond, Philadelphia, J. S. Codman, Boston, and G. C. Keech, Chicago; Secretary, P. S. Millar, New York; Treasurer, A. H. Elliott, New York; Directors, A. S. McAlister, New York; E. N. Wrightington, Boston, and Geo. R. Green, Philadelphia.

BROOKLYN ENGINEERS CLUB.—At the regular meeting in the Brooklyn (N. Y.) Library Building, Jan. 14, Mr. Arthur I. Perry, Assistant Engineer of the Department of Bridges of New York City, presented a paper entitled "The Manhattan Bridge Cables." With the help of numerous lantern-slide illustrations from photographs taken during the stringing of the cable wires, the paper gave an intimate idea of the methods employed from the construction of the workmen's footwalks to the final squeezing into shape of the completed cables with hydraulic clamps. The anchorages and tower connections were also described. The club has decided to rent a club-house to take the place of the rooms now occupied in the Library Building.

CANADIAN SOCIETY OF CIVIL ENGINEERS.—The business sessions of the annual meeting in Toronto, Ont., Jan. 28-30, will be held in the banquet hall of the King Edward Hotel. On the evening of Jan. 28 the retiring President of the society, Dr. John Galbraith, will address a meeting of the members in the Convocation Hall of Toronto University. After the address the undergraduates of the faculty of Applied Science of Toronto University will entertain the society at dinner. The second day of the meeting will be devoted to excursions to the Canadian Westinghouse Co. and International Harvester Co., at Hamilton, the recently completed elevators at Port Colburne, and the works of the Plymouth Cordage Co., at Welland. Business meetings are held on Thursday and Saturday mornings, Jan. 28 and 30.

WESTERN SOCIETY OF ENGINEERS.—The program for the present season includes the following papers, but it is announced that this is a tentative program only and that the dates and topics are subject to change: Jan. 15, "Corrosion in Steam Boilers as an Electro-Chemical Phenomenon," by Prof. C. S. Burgess; Jan. 20, "Steel Castings," by R. P. Lamont; Feb. 3, "Tests on Heavy Pulley Blocks and Wire Cables," by J. H. Prior; Feb. 17, "Manganese Steel," by W. S. Potter; March 3, "The Chicago Harbor and River," by John M. Ewen; March 17, "Recent Development in the Manufacture and Use of Portland Cement," by S. B. Newberry; April 7, "The Reconstruction of the Street Railway Tracks in Chicago," by George Weston; April 21, "Protective Coatings for Structural Materials," by R. S. Perry.

OHIO ENGINEERING SOCIETY.—The program for the 30th annual convention, to be held in Columbus, Ohio, Jan. 26-28, includes the following papers: "Road Problems in Ohio," James C. Wonders, State Highway Commissioner; "An Economical Long Span Reinforced-Concrete Highway Bridge," W. J. Watson, Cleveland; "Table of Short Radius Curves," W. H. W. Jenkins; "Coal Mining," Prof. N. W. Lord; "Grade Crossing Elimination in Columbus, Ohio," R. H. Simpson, Assistant City Engineer; "The Operation of the Columbus Sewage Purification Works," C. B. Hoover, Superintendent in Charge; "The State Board of Health and Engineering Problems," Dr. C. O. Probst, Executive Officer of the State Board of Health; "The Operation of Water Purification and Softening Plants with Special Reference to the Works at Columbus," Wm. R. Copeland, Superintendent in Charge.